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Changes in Vegetation and Land Use in Eastern Colorado

A Photographic Study, 1904 to 1986

ABSTRACT

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This publication assesses the vegetational changes that have taken place in eastern Colorado as a result of land use and changes in weather patterns.

Keywords: blowouts, bunchgrasses, ecology, plant communities, plant succession, sandhills-mixed grasses, shortgrasses, tree claims.

Sales Information

Copies of this publication can be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA, 22161.

Illustrations of plant specimens have been reprinted from the following:

U.S. Department of Agriculture. 1970. "Selected Weeds of the United States." U.S. Department of Agriculture, Agriculture Handbook No. 366.

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PREFACE

This publication had its conception in the land-use studies and photographic records of the eminent plant ecologist and geographer, Homer L. Shantz.

Shantz was born in Michigan in 1876, attended high school in Colorado and graduated from Colorado College with a major in botany in 1901. He taught at Colorado College before receiving his Ph.D degree at the University of Nebraska in 1904. It was during this period that he became interested in photographing vegetation along the transition zone between the plains and mountains of eastern Colorado. Most of his photographs in this area were taken in 1904 and 1905.

Shantz spent the years 1908-1917 at the U.S. Department of Agriculture's Central Great Plains Research Station (Akron Experiment Station, also known as the U.S. Dryland Station), east of Akron, Colorado. His principal activities were related to dryland agricultural studies, with emphasis on water relationships of plants. His pioneering studies with Lyman Briggs produced notable contributions to understanding water requirements of plants, soil and climate relationships of vegetation, and the use of native vegetation as an indicator of agricultural potential of soil and climate. He also found time to photograph vegetation and to obtain data on land use in eastern Colorado and numerous other locations in the western United States.

Shantz again visited the plains area in 1937 and 1940 to assess the effects of the great drought of the 1930's. In 1949 he recorded the recovery of vegetation after the favorable years of the 1940's and reported changes that had occurred since his studies in the early part of the century. He also visited the area briefly during the dry years of 1953 and 1955 with William G. McGinnies and, with him as junior author, prepared a draft manuscript based on some of his studies at Akron and his photographic records. However, the manuscript was never completed.

In the 1980's William J. McGinnies, son of William G. McGinnies, became interested in studying vegetation in eastern Colorado and in 1985 and 1986 visited all of Shantz' photo points. The present manuscript is based on Shantz' early photographs, some of his land-use studies, and W. J. McGinnies' repeat photographs in 1985 and 1986. Parts of the unpublished manuscript "Changes in Natural Vegetation and Land Uses on the Plains and Along the Eastern Mountain Front in Colorado" by H. L. Shantz and W. G. McGinnies served as a starting point for this publication.

The interpretation of vegetation changes through 1955 are basically those of Shantz, but modifications have been made in light of the 1985-1986 observations. The most important part of this manuscript is the record of the plants that were present at each photo period. This is the ecological record of changes of value to present ecologists and the basis for all future ecological studies. The overall conclusions are those of W. J. and W. G. McGinnies, and they are solely responsible for any errors of fact or interpretation; but in no case do their conclusions differ appreciably from those of Shantz.

W. J. McGinnies passed away before this manuscript was published. He alone should be credited with the 1985 observations and photographs and the writing of the entire manuscript.

Others who assisted in this study include Charles T. Mason, Jr., University of Arizona, who provided photographic prints from the University of Arizona Herbarium Archives; T. K. Eaman, U.S. Soil Conservation Service (retired), A. R. Grable, Agricultural Research Service (retired), R. M. Turner, U. S. Geological Survey, and C. H. Wasser, Colorado State University (retired), who provided detailed technical reviews of the manuscript; C. M. Yonker, Colorado State University, who aided in soil descriptions; and M. G. Calvert, Agricultural Research Service, and C. H. Wasser, who helped with plant taxonomy in 1985-1986. After the death of W. J. McGinnies, D. N. Hyder, Agricultural Research Service (retired), C. H. Wasser, and C. E. Townsend, Agricultural Research Service, completed the editing of the manuscript.

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Figure 1.
Map of eastern Colorado showing counties, principal towns, and cities mentioned in this publication.

Changes in Vegetation and Land Use in Eastern Colorado

A Photographic Study, 1904 to 1986

William J. McGinnies, Homer L. Shantz, and William G. McGinnies

INTRODUCTION

The natural vegetation of any part of the earth's surface reflects the dynamic interactions between soil, weather, and animal life. Natural vegetation, if properly interpreted, reveals the climatic conditions under which it was produced, the kind of soil on which it grew, and how the land on which it grew had been used. Weather in particular varies greatly from year to year; thus, to survive, the vegetation must have the resilience to adjust or adapt to direct and indirect weather effects.

Because of these interrelationships, the changes or lack of change in vegetation over time can help us establish land-use patterns and develop sound land-management plans. In particular, the study reported herein shows the interactive effects of time, climate, weather, soils, and land use on vegetation and vegetation dynamics in eastern Colorado.

Shantz' observations and photographs in the early part of the century provide a unique record. With this record, we can follow changes in vegetation over a period of 70 to 80 years by means of accurately sited repeat photographs, specific and detailed observations, and lists of plants present on the sites. Although there are gaps in the records over the years and no specific information on grazing is available, major trends in vegetation and land use are documented. This publication makes these photographs, observations, and lists of plants readily available to those wishing to evaluate the future trends and changes that surely will occur.

The locations of the principal study areas are shown on the map of eastern Colorado (figure 1). The most intensively studied areas were in Yuma and El Paso Counties; but study sites also extended along the eastern edge of Colorado from Phillips to Baca Counties and west to Washington, Lincoln, and Otero Counties, with additional sites in Douglas and Pueblo Counties. The basic records include sequences of repeat photographs of specific plant communities together with observations and lists of species making up the plant cover.

Deceased, biological science collaborator and formerly range scientist, U.S. Department of Agriculture, Agricultural Research Service, Fort Collins, Colorado; deceased, formerly plant physiologist, U.S. Department of Agriculture, Bureau of Plant Industry, and Forest Service; and deceased, director emeritus, Office of Arid Land Studies, University of Arizona, Tucson.

Climate

The climate of eastern Colorado is cool and semiarid. Average annual precipitation ranges from about 18 inches at Wray to about 12 inches at Las Animas and from about 16 inches at Colorado Springs to about 19 inches at Monument. Approximately 70 percent of the precipitation falls in April through August and only about 10 percent in November through February. At Colorado Springs and Monument, June receives less rainfall than May, July, or August. Weather varies greatly from year to year, and recurrent droughts are the rule. Severe droughts occurred during the 1930's, 1950's, and 1970's. At the U.S. Department of Agriculture's Central Great Plains Research Station near Akron, average annual precipitation was 16.47 inches for the period 1908 to 1985, but it ranged from a low of 9.93 inches in 1939 to a high of 26.99 inches in 1946 (figure 2). In 16 of the years between 1908 and 1985, precipitation was less than 80 percent of the average. Note the general downward trend in average annual precipitation at Akron (regression line in figure 2). An exceptionally wet period occurred during the 1940's and a less wet period started in 1979 and extended into the 1980's. These wet and dry years must be taken into account when interpreting the photographs and observations reported here. In addition to the wide year-to-year variations in precipitation, localities frequently differ widely in precipitation within a given year. In any such year, it is not uncommon for one county to have above-normal precipitation and an adjacent county to have below-normal rainfall. On an even smaller scale, one location can receive a heavy summer rainstorm while an area only a few miles away receives no rain.

Average daily temperatures in eastern Colorado are 28°F for January, and 74°F for July. During most years, the maximum temperature nears or exceeds 100°F on some days except in the Colorado Springs area where

the maximum is about 10 degrees lower. Some winter days have minimum temperatures lower than -10°F. A continuous snow cover during the winter months is rare, so the vegetation receives little protection from the cold, windy weather. The average frost-free growing season is about 150 days, ranging from 120 to 130 days in the foothills of the Rocky Mountains to about 170 days in the southeastern part of the State.

Land Form and Soils

In Colorado, the Great Plains consists of a broad, nearly flat but irregular surface that rises from an elevation of 3500 to 4000 feet along the border with Kansas and Nebraska on the east to more than 5000 feet on the west where the plains meet the foothills. Most of the area is part of the high plains section of the Great Plains province, but the northwest portion of the area is part of the Colorado piedmont. The principal rivers draining the plains are the South Platte in the north and the Arkansas in the south. In the east-central area between these two major rivers, the Republican, Arikaree, and Smokey Hill Rivers and their tributaries drain eastward toward Kansas and Nebraska.

Soils on the plains have been formed on four principal physiographic types: (1) upland areas underlain by sedimentary formations, (2) upland areas underlain by loess, (3) upland sandy areas, and (4) valley areas. The areas underlain by sedimentary materials are usually level to gently rolling, but outcrops of some of the more resistant rocks provide the caps for some small mesas. Sedimentary formations range from gravels to sandstones to shales. In some locations, the sedimentary material is capped by a few inches to a few feet of loess. This loess cap is not to be confused with the upland areas where the covering of loess may be up to 85 feet in thickness. The deep loess areas are mostly on tablelands. The upland sandy areas are characterized by sandy lands and dunes that overlie sedimentary formations. Maximum local relief of the dunes is usually less than 150 feet. Blowouts, depressions caused by wind-induced removal of sand, are mostly revegetated and common in these areas. Some dune areas overlie loess, and the dune particles grade from sand into silt. Valley areas are formed primarily on flood plains of the major drainages but also include the valley slopes that lie between the flood plains and the upland areas. Soils near Colorado Springs have been formed on sedimentary outcrops, outwash from the Rocky Mountains, and weathered granitic materials.

Soils of the Colorado plains are typically Mollisols, Aridisols, or Entisols. Mollisols are base rich and have

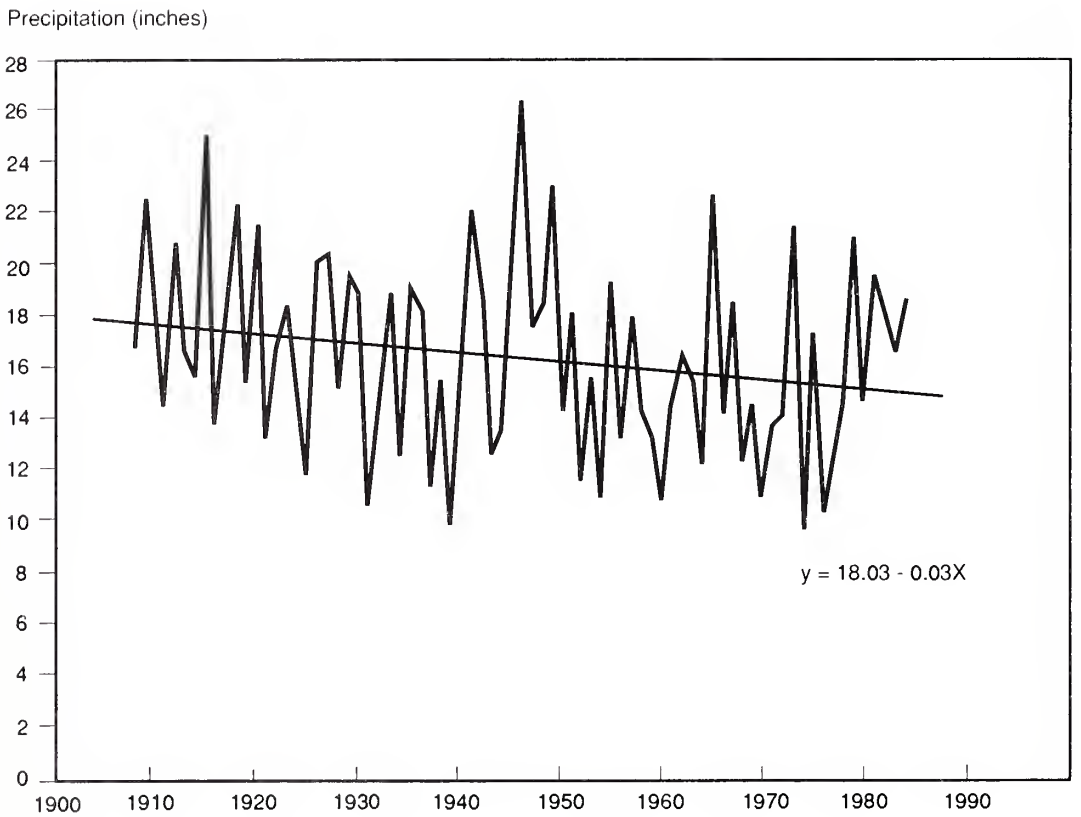


Figure 2.
Annual precipitation, 1908 to 1985, at the U.S. Department of Agriculture's Central Great Plains Research Station, near Akron, Colorado.

a characteristically dark surface horizon from the accumulation of organic carbon. Aridisols do not have water available for mesophytic plants for long periods; typically the surface horizons are light in color. Entisols give little or no evidence of horizon development for such reasons as resistance of the parent material to weathering in its present climate or the frequent or recent deposition of alluvium, as on floodplains. Soils of the northern half of the Colorado plains, in decreasing order of extent, include Mollisols classified as Argiustolls and Paleustolls, Aridisols typified by Haplargids, and Entisols that include Torripsamments and Torriorthents. Soils of the southern half of the Colorado plains, in decreasing order of extent, are Aridisols classified as Haplargids and Camborthids, Entisols including Torripsamments and Torriorthents, and Mollisols which are mostly Argiustolls. Soils of the Black Forest area of El Paso, Elbert, and Douglas Counties are Mollisols classified as Haploborolls and Argiborolls, and Alfisols classified as Eutroborolls. Alfisols are base rich, have surface horizons which are light in color, and have a clay accumulation in the subsoil. Soils of the sandy plains and sandhills are Entisols which are classified as Torripsamments. These occur along the South Platte River (mostly on the south side) in Weld, Morgan, Washington, Logan, and Sedgewick Counties; over a large part of Yuma County; along the south side of Big Sandy Creek in Elbert, Lincoln, Cheyenne, Kiowa, and Prowers Counties; along the south side of the Arkansas River in Otero, Bent, and Prowers Counties; and in a small area in southern El Paso and northern Pueblo Counties.

Soil textures range from clayey to silty to sands; and as will be shown in this publication, texture, because of its effect upon permeability, has a great effect on the vegetation. Permeability also affects the depth to the layer of carbonate accumulation. On the clayey and loam soils ("hard lands"), the carbonate layer is usually 12 to 18 inches under the surface; but as the soil texture becomes coarser and more permeable, or the precipitation becomes greater, the carbonate layer lies at lower depths and may be almost nonexistent in sandy soils. Soil texture is influenced primarily by parent material and by whether or not this material is overlaid by a deposit of loess or alluvium. Because of the sparseness of the vegetation, particularly during droughts, the soil surface is frequently subject to both wind and water erosion or deposition, which also can affect surface soil texture and microrelief.

Vegetation

The natural vegetation of eastern Colorado varies more than might be expected for an extensive, low-gradient sloping plains surface. The variation results from differences in topography, soil texture, precipitation, and temperature.

By far the most common vegetation in eastern Colorado is the "shortgrass type."[1] It occurs primarily on loam and clay loam soils. The shortgrass type, particularly if grazed, gives the impression of monotonous uniformity that sometimes resembles a lawn. The dominant species is *Bouteloua gracilis* (see list of scientific and common plant names in the appendix). This species may occur in almost pure stands on the western part of the Colorado shortgrass type; but farther east, *Buchloe dactyloides* is a common codominant. Subdominant species commonly found associated with the shortgrasses include *Gutierrezia sarothrae, Aristida longiseta, Psoralea tenuiflora, Opuntia polyacantha, Sporobolus cryptandrus, Hilaria jamesii* (in the south), *Yucca glauca*, and *Agropyron smithii*.

Shantz called a variant of the shortgrass type the "wiregrass type" (wiregrass was the local common name for *Aristida longiseta*). This type occurs on silt loam and sandy loam soils that are more permeable to rainfall than the finer textured soils on which the shortgrass type generally occurs. The deeper percolation of water permits the deeper rooted species such as *Aristida longiseta* to coexist with the shortgrasses. The dominant species of the wiregrass type are *Bouteloua gracilis* and sometimes *Buchloe dactyloides*, but there is also an abundance of deep-rooted species that include *Aristida longiseta* and *Psoralea tenuiflora*. In grazed areas vegetated with both wiregrass and shortgrass types, the shortgrasses and palatable species in the wiregrass type will have been closely cropped while the relatively unpalatable *Aristida longiseta* remains ungrazed and appears as an open overstory (see figure 14A). The wiregrass type as defined here is not to be confused with the grasses that notably include *Aristida longiseta* and that are commonly seen in secondary succession following perturbation, particularly plowing, of the shortgrass type. Secondary succession is an intermediate step in plant succession. The wiregrass type described here is in the final stage of succession on more permeable soils.

Where the soils are sandier and more permeable than soils under the wiregrass type, the "bunchgrass type" occurs as a transition between the wiregrass type and the sandhills type (bunchgrass was the local common name for *Schizachyrium scoparium*). Soil permeability is even greater and water percolation deeper under the bunchgrass type than under the wiregrass type. The dominant species is *Schizachyrium scoparium* (formerly listed as *Andropogon scoparius*), which, when ungrazed, can be recognized by its reddish-brown color. Associated species include

[1]The term "type" is used in this publication partly because the authors are not sure as to the appropriateness of the various ecological terminologies and classifications that have been applied to the Great Plains. The terms "shortgrass," "wiregrass," "bunchgrass," and "sandhills-mixed" are used to describe types of vegetation, in agreement with H. L. Shantz' other publications.

Bouteloua hirsuta, Andropogon hallii, Calamovilfa longifolia, Aristida longiseta, Panicum virgatum, Psoralea tenuiflora, Bouteloua gracilis, Artemisia filifolia, and *Yucca glauca*. This type also commonly grows on clay or silt loam ridges or "breaks," where soil is loose and rapidly eroding, but in more scattered stands than on sandy soils. It also occurs on gravely soils near the mountains and, farther east, on loam soils where moisture conditions are more favorable.

The "sandhills-mixed type" occurs on soils that are even sandier than those that sustain the bunchgrass type. Essentially all the precipitation that falls on this type infiltrates, and soil water is often available at deeper depths. The vegetation is much more variable than the other plains grass types. In some places the vegetation appears to consist entirely of tall bunchgrasses; in other places, mainly spreading tall grasses; and in yet other places, a mixture of tall grasses, midheight grasses (midgrasses), and short grasses. The dominant species of the sandhills-mixed type are *Calamovilfa longifolia, Andropogon hallii, Aristida longiseta, Bouteloua hirsuta, Bouteloua gracilis, Artemisia filifolia, Redfieldia flexuosa*, and *Psoralea tenuiflora*. Other common species include *Panicum virgatum, Ipomoea leptophylla, Yucca glauca, Schizachyrium scoparium, Sorghastrum nutans, Bouteloua curtipendula, Stipa comata*, and *Mentzelia nuda*.

Within areas vegetated with the sandhills-mixed type are numerous blowouts. These vary from a few feet to as much as 100 feet in depth, and from less than 50 feet to over 2000 feet in diameter. Soils in blowouts may be mostly bare, coarse sand if newly formed, or they may be completely revegetated. In the early stages of colonization, the dominant species are *Redfieldia flexuosa, Psoralea lanceolata, Muhlenbergia pungens, Petalostemon, villosum* and *Oryzopsis hymenoides*. These are followed by *Calamovilfa longifolia, Andropogon hallii*, and many of the other species common to the sandhills-mixed type as the blowout stabilizes. In both the sandhills-mixed type and in the vegetation in blowouts, *Artemisia filifolia* has generally increased greatly in recent years.

The foothills type extends in a narrow band along the transition zone between the plains and mountains from south of Colorado Springs northward to the Wyoming border. Because the soil parent materials, topography, and elevation in this zone vary widely, the foothills type is by far the most variable in eastern Colorado. The principal grasses are *Bouteloua gracilis, Agropyron smithii, Bouteloua curtipendula, Stipa comata*, and *Schizachyrium scoparium*. Woody plants include *Cercocarpus montanus, Rhus trilobata, Quercus gambelii, Eurotia lanata, Juniperus monosperma*, and *Pinus ponderosa*. Other species may be locally abundant, particularly on the slopes and hills. *Pinus ponderosa* is abundant in the Black Forest northeast of Colorado Springs, with *Poa pratensis, Festuca idahoensis*, and other montane grasses common in the understory. Vegetation in the natural openings ("parks") within the forest consists of a mixture of plains and montane species.

Settlement of the Plains of Colorado

Eastern Colorado was obtained from France by the Louisiana Purchase in 1803 and by the Spanish American Compromise Boundary of 1819. Major Stephen B. Long traversed the Great Plains in 1819 and 1820 and called the area the Great American Desert. In the middle of the 19th century, many groups crossed the plains but did not settle the region because it lacked trees and water. Nomadic Indian tribes, who depended on bison for food, were the only permanent inhabitants of the Colorado plains until after 1860.

The agricultural development of the plains area of Colorado began in the 1860's near the mountains, where numerous small farms were established to supply food to the mining communities in the mountains. Stock raising also began in a small way close to the mountains during the 1860's. During the 1870's, bison were largely eliminated from the plains and most of the nomadic Indians were moved to reservations. Large herds of cattle moved northward from Texas in the late 1870's, and a range livestock industry was established on the plains. By the early 1880's, nearly all the land where water was available was being grazed by cattle. The open-range cattle industry peaked in the mid-1880's but immediately started to decline following the winter of 1886 because of its severity and the drop in cattle prices. However, almost all the native rangeland of the plains has been grazed by livestock from the 1880's to the present time.

A few homesteaders began dryland farming on the plains beginning in the late 1870's, and the number increased slowly during the 1880's. Many of these farms were abandoned during the mid-1890's because of a severe drought and depressed prices. A few lands also were settled and patented under the Timber Culture Act between 1873 and 1891. Settlement of the plains continued at a slow but steady rate until the beginning of World War I. During and following the war, there was a great demand for wheat, and many acres of native rangeland were plowed and planted to wheat. During the late 1920's, mechanized farming made possible the development and farming of even larger acreages of dryland wheat. During the 1930's, the combination of drought and the Great Depression resulted in the abandonment of many of the dryland farms in what came to be known as the Dust Bowl. During and following World War II, demand for wheat again increased; and much rangeland was plowed and planted to wheat, including farmland that had previously been abandoned. During the late 1970's and early 1980's, some additional grassland was plowed, generally on soils poorly suited for farming. In the early

period of settlement, most dryland farmers planted corn, but they gradually shifted to planting wheat, except for a limited acreage of sorghum. Much of the better farmland in eastern Colorado has remained in dryland wheat production.

Irrigation was begun along the major rivers and streams, and irrigation development continued past the middle of the 20th century. At present, more and more water is being diverted from irrigated agriculture to urban domestic and industrial uses. During the late 1960's and in the 1970's, center-pivot irrigation systems became common in extreme eastern Colorado. These systems use water pumped from the Ogallala Aquifer to irrigate good agricultural soils as well as lands that are too sandy for dryland farming.

During the settlement of the plains, many small towns and school districts were established. Over the years, most of the smaller farms were consolidated into larger and larger land holdings and the farm population declined. The rural schools are now mostly gone and the smaller towns have declined in size or, in some cases, been abandoned. Farm mechanization, low crop prices, and modern methods of travel have been largely responsible for these changes.

Methods and Procedures

The first series of photographs of vegetation in eastern Colorado was taken between 1904 and 1916 by H. L. Shantz. The general aspects of the vegetation were described, and a list was made of the most important species. All photography was on 4- by 5-inch negatives. Some additional sites were first photographed in 1937 and 1940 to show the effects of the drought of the 1930's. The areas covered included the plains and sandhills of eastern Colorado, the transition zone between the plains and foothills near Colorado Springs, and the edges of the Black Forest northeast of Colorado Springs. Most of these photographs were made while Shantz was employed by the Bureau of Plant Industry, U.S. Department of Agriculture.

In 1949, Shantz, accompanied by Ned A. Smith, took photographs of 189 previously photographed sites (including some photographs of the mountains west of Colorado Springs that were not considered for this publication). This work was supported by the Rocky Mountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. Again, the photographs were made on 4- by 5-inch negatives. Because a lens identical to the one used in previous years was not available, in some cases out-of-focus photographs were the result of attempts to compensate for differences in focal lengths. Two exposures were made at each site. One negative was to have been placed in the permanent files of the Forest Service. These negatives cannot be found. The second negative for each site is now in the archives of the herbarium of the University of Arizona in Tucson. A mimeographed report, "Changes in Vegetation and Land Use in Eastern Colorado, 1904 to 1949," by H. L. Shantz and Ned A. Smith, was prepared in 1953; and a memorandum, "Notes on photo sites of pictures taken by Dr. H. L. Shantz from July 3 to August 17, 1949," was written by Ned A. Smith in 1949. These two items are in the H. L. Shantz special collections in the library of the University of Arizona, as are copies of Shantz' field notebooks.

During 1985 and 1986, W. J. McGinnies rephotographed about 90 of the sites photographed in 1949. Usually, the exact locations previously photographed were found, and camera photo points were within a few feet of those used previously. The few exceptions are noted in the text. Photographs were taken with a 35-mm camera equipped with a lens of 35-mm focal length. This lens covered a field of view slightly greater than that covered by Shantz' lens. These photographs were cropped in the darkroom to provide the same field of view and perspective as those of the earlier photographs. All photographs were taken through a medium yellow filter on Eastman Panatomic-X film developed in a compensating developer. These negatives will be filed with the original Shantz negatives at the University of Arizona Herbarium, and field notebooks will be added to the Shantz special collection at the University of Arizona Library. The 1985-86 repeat photography was funded by the Agricultural Research Service, U.S. Department of Agriculture. The location of the photo point for each photograph has been described by section, township, and range. Also, the photo number for each figure is listed. The 1949 photographs bear two numbers; the digits following the hyphen in the first number form the number assigned to the photograph in the 1953 Shantz and Smith report, while the second number is the negative number used in the University of Arizona Herbarium collection.

Scientific names in this publication are in accordance with the usage of the Colorado State University Herbarium. Photograph location names are those assigned by Shantz, although, because of changes in land ownership, the names do not always reflect the current owner's name.

Land use from Seibert to Haxtun was recorded along the same route in 1949 and 1985. Land use was recorded every mile in 1949, and every half-mile on both sides of the road in 1985. Land use in Yuma Township was mapped on grid paper in 1908 and 1949, and on aerial photographs in 1985. In 1985, for statistical purposes, those quarter-sections containing a center-pivot irrigation system were assumed to be 160 acres of irrigated land, although the corners of the quarter-sections frequently were not irrigated.

CHANGES IN SHORTGRASS VEGETATION ON HARD LAND IN EASTERN COLORADO

Soils of the Hard Lands

On the high plains of Colorado, the loam soils are primarily Aridic Ustolls, Ustolls, Ustic Aridisolls, and Terriorthents, light-colored soils of the arid region. They are known locally as "hard land." These soils are mostly shallow, not because of parent material but because only the surface soil is moistened by precipitation, the subsoil remaining dry. Typical surface soil is dark grayish-brown and is a mellow silt but may vary locally from a silt to a clay loam. Below this the soil is finer textured and of crumb or somewhat columnar structure, and it overlies a deposit of lime at a depth of 12 to 18 inches. The surface layer of soil contains the mass of grass roots, although the roots of a few perennials reach deep into the soil beyond the deposits of lime. In dry years, plant growth is confined to May, June, and early July. By the middle of July, available soil moisture stored during fall, winter, and spring is usually exhausted. Soil moisture may be briefly replenished by high-intensity summer storms.

The shortgrass vegetation typical of these hard lands is dominated largely by two grasses—*Bouteloua gracilis* and *Buchloe dactyloides*. However, a great many other plants occur from time to time, and the floristic composition varies from year to year and among different locations. The presence of other species generally can be explained by local climatic, physiographic, soil textural, or soil moisture differences; disturbances by fungi, animals, or humans; or seasonal growth patterns of the different species. Many of these local variations are documented in figures 3A through 13C.

Akron, Seibert, and Hugo

The native sod of the Central Great Plains Research Station, east of Akron, before it was plowed consisted of a rather dense shortgrass cover (figure 3A). The proportion of *Bouteloua gracilis* and *Buchloe dactyloides* varied from place to place. In one location, *Buchloe dactyloides* occupied about 27 percent of the soil surface and *Bouteloua gracilis* about 21 percent. At a nearby location *Bouteloua gracilis* occupied 24 percent and *Buchloe dactyloides* 20 percent of the ground cover (figure 3B). Small *Festuca octoflora* were abundant in grass mats but nearly absent from the open soil areas between the mats. Other species were *Gutierrezia sarothrae, Sitanion hystrix, Artemisia frigida, Stenophanomeria tenuifolia, Heterotheca villosa, Psoralea tenuiflora, Aristida longiseta, Agropyron smithii, Astragalus mollissimus, Linum rigidum, Ratibida columnifera, Haplopappus spinulosus, Grindelia squarrosa, Sphaeralcea coccinea, Schedonnardus paniculatus, Astragalus crassicarpus, Astragalus gracilis, Liatris punctata, Opuntia polyacantha, Sophora sericea, Koeleria cristata, Erigeron canus*, and small annuals such as *Festuca octoflora* and *Plantago patagonica*..

The composition of the vegetation varied with soil texture and type of disturbance. In the swales, *Agropyron smithii* was often dominant because of the more favorable moisture regimes. At the ends of the Burlington Railroad right-of-way within a firebreak, where the vegetation was recurrently burned, *Buchloe dactyloides* gave way largely to *Bouteloua gracilis*. Where prairie dogs or badgers had burrowed and the calcareous subsoils were brought to the surface, many *Sphaeralcea coccinea, Gutierrezia sarothrae, Aristida longiseta, Muhlenbergia torreyi*, and *Buchloe dactyloides* were usually present. Plants in the breaks, on roads, and in abandoned fields were chiefly annuals.

West of Seibert in 1907 a large area was vegetated chiefly by *Buchloe doctyloides* and *Bouteloua gracilis* (50 to 60 percent ground cover), with *Artemisia dracunculus* scattered evenly over the shortgrasses (figure 4). Because the soils west of Seibert tended toward a sandy texture, vegetative composition also included *Sophora sericea, Gutierrezia sarothrae, Opuntia polyacantha, Sphaeralcea coccinea, Psoralea tenuiflora, Echinocereus viridiflorus, Haplopappus spinulosus, Grindelia squarrosa*, and others.

One mile northeast of Hugo (figure 5), on a clay soil, the vegetation in 1907 was rather sparse and consisted of *Bouteloua gracilis* and *Buchloe dactyloides*, with a large amount of *Opuntia polyacantha*. Prairie dog mounds were common, and on these disturbed areas grew *Heterotheca villosa, Haplopappus spinulosus, Schedonnardus paniculatus, Muhlenbergia torreyi, Grindelia squarrosa*, and *Dyssodia papposa*. These areas had all been plowed by 1949 and no repeat photographs were possible.

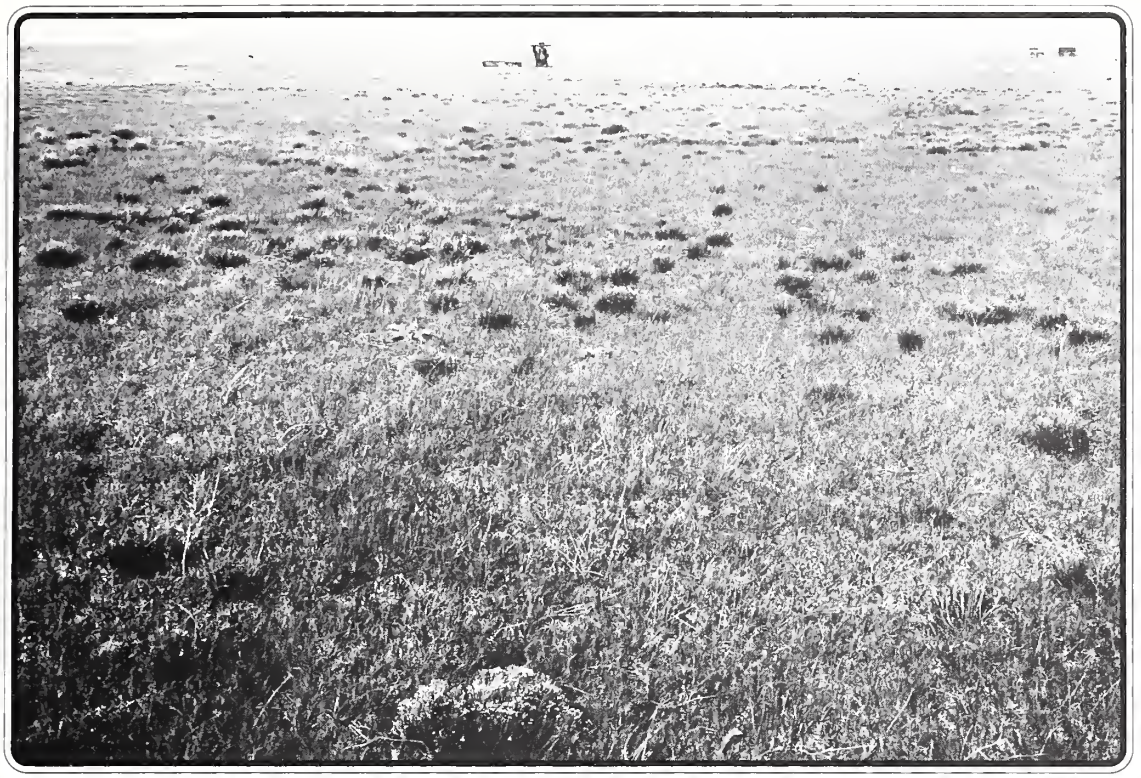


Figure 3A.
June 27, 1907, Central Great Plains Research Station, east of Akron.
(Photo No. 1907-34)

Figure 3B.
August 17, 1907, near Central Great Plains Research Station, east of Akron.
(Photo No. 1907-97)

Figure 4.
August 25, 1907, between Flager and Seibert. (Photo No. 1907-120)

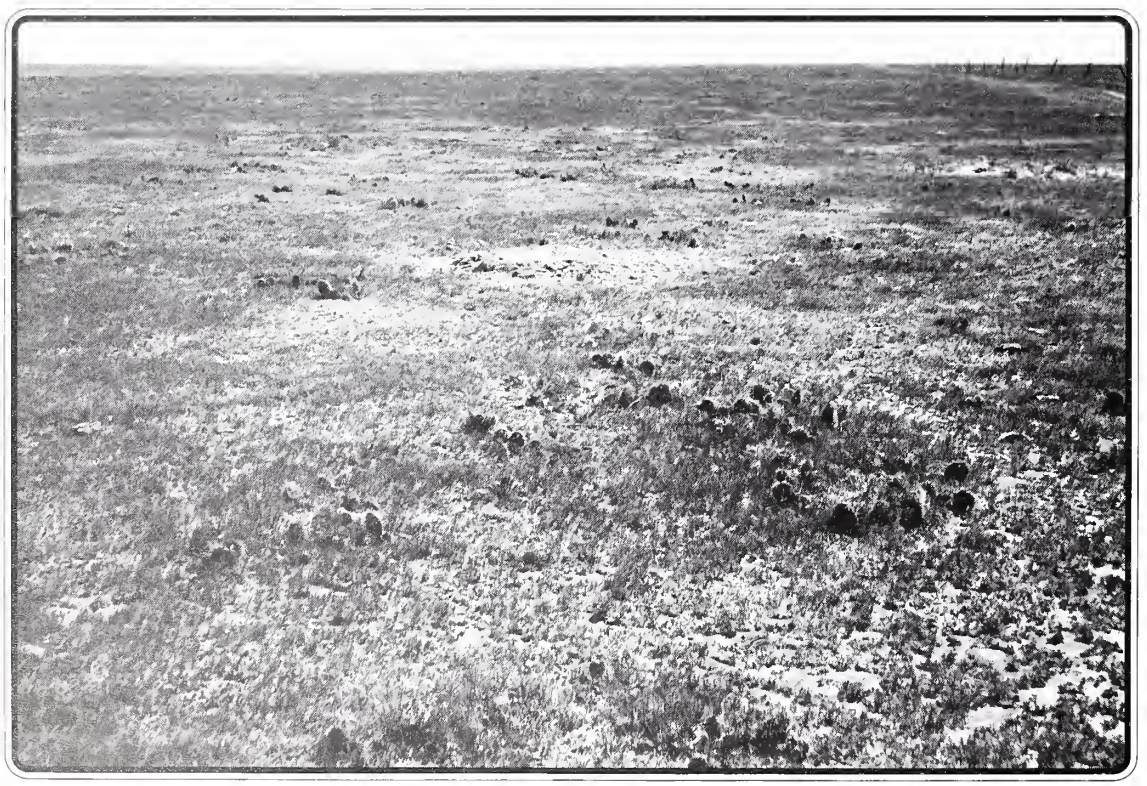


Figure 5.
August 24, 1907, 1 mile northeast of Hugo. (Photo No. 1907-118)

Near Firstview and Burlington

Some of the variations resulting from local differences in soil, weather, and land use are brought out by the next series of photographs of typical hard land areas in eastern Colorado.

In 1907 shortgrass vegetation at a point west of Firstview, (figure 6A) was a rather open stand of 65 percent *Bouteloua gracilis* and about 8 percent *Buchloe dactyloides*. The fact that this area was inside the firebreak and subject to recurrent fire probably accounted for the low percentage of *Buchloe dactyloides*. The firebreak on the left and a prairie dog mound in the foreground were occupied by *Schedonnardus paniculatus*.

In 1937 this same site was nearly bare of vegetation (figure 6B). The shortgrass cover had been grazed, weakened by drought, and whipped off by wind and blown soil. Nothing green showed, but the crowns and roots of some of the shortgrass plants still held the loam soil in place.

In 1949 a good open stand of *Bouteloua gracilis* constituted 80 percent of the species composition on the site west of Firstview (figure 6C), a cover as good as ever seen in this region. There were a few *Buchloe dactyloides* but much less than in 1907. Since 1937 the soil surface between the bunches or mats of *Bouteloua gracilis* had been lowered by wind erosion. This probably happened during the two very dry years 1938 and 1939. Vegetative composition also included *Schedonnardus paniculatus*, *Sporobolus cryptandrus*, *Aristida longiseta*, *Solanum rostratum*, *Helianthus annuus*, and *Grindelia squarrosa*.

By 1985, this location had been plowed and planted to wheat for several years. On August 27, when the site was visited, the field was covered with a stand of wheat stubble, which was adequately protecting the site from erosion. Most of this region now has been cultivated and planted to wheat. Almost no native grassland remains. Conservation farming is the exception, and few fields are left in stubble like that shown in figure 6D. This general region, Cheyenne and Kit Carson Counties, was in the very heart of the Dust Bowl during the 1930's.

South of Burlington there was an unusually severe drought in 1907. Precipitation was below normal from April to August and was 6 inches below normal for the year. The vegetation was almost pure *Bouteloua gracilis* and *Buchloe dactyloides*, with a cover of about 25 percent each and no other plants showing above the shortgrasses. Even these shortgrasses showed no flower stalks and were dry and brittle on August 21 (figure 7A). So dry were the grasses that the leaves crumbled under foot. There were few annual or perennial forbs except in disturbed areas. Other perennials present on the site were *Gutierrezia sarothrae*, *Psoralea tenuiflora*, *Psoralea lanceolata*, *Opuntia fragilis*, *Sphaeralcea coccinea*, *Oxybaphus linearis*, *Ratibida columnifera*, and *Grindelia squarrosa*, but these were inactive. There was also an occasional *Helianthus annuus* seedling.

Akron had 11.19 inches of rain in July and August 1907, while Burlington, some 80 miles to the southeast, had only 2.67 inches. The contrast in flowering of *Bouteloua gracilis* between Akron and the area south of Burlington was especially striking. At Akron, on August 17, 1907, there was a healthy growth of *Bouteloua gracilis*—sometimes in an almost pure stand—the flower stalks being over a foot high (figure 3B). By contrast, at Burlington, there were no flower stalks (figure 7A).

The site near Burlington was photographed again in 1937 and showed changes similar to those at Firstview (figure 7B). *Bouteloua gracilis* and *Buchloe dactyloides* had been severely damaged by drought, and only their crowns and roots remained. The bulk of the sparse vegetation consisted of scattered *Salsola iberica*, *Lepidium densiflorum*, *Chenopodium leptophyllum*, and *Plantago patagonica* (figure 7B). The deterioration of soils and vegetation was widespread in eastern Colorado in 1937, and the ground was nearly bare over wide areas.

When the area south of Burlington was visited in 1985, no native vegetation could be found anywhere near where the previous photographs had been taken. Most of the land had been plowed and was used for growing wheat, and the fields were clean-tilled from fence to fence with no stubble left to protect the soil. This land is among the most productive wheatlands in Colorado, but it is also in the region that was the most severely affected by erosive winds during the Dust Bowl period of the 1930's.

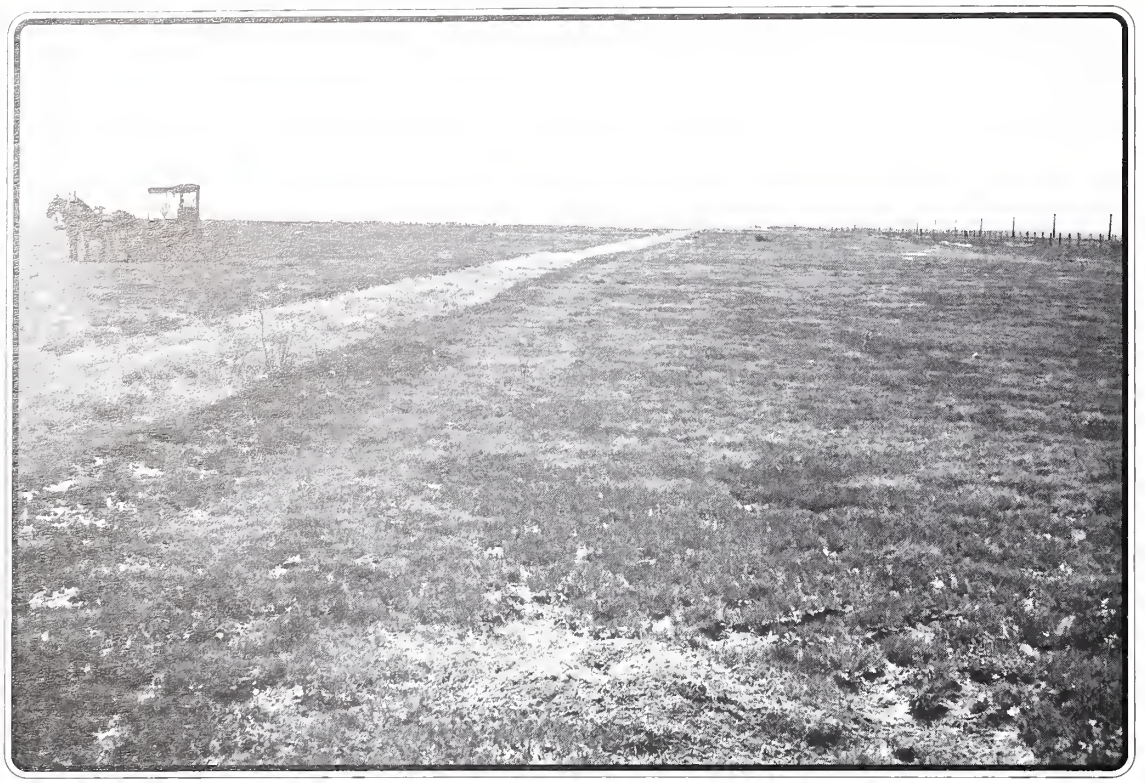


Figure 6A.
August 22, 1907, 1.5 miles west of Firstview, looking west, Union Pacific Railroad on the right. (Sec. 21, T14S, R46W; Photo No. 1907-112)

Figure 6B.
May 25, 1937, looking south from the same point as in figure 6A. (Photo No. G-10-1937)

Figure 6C.
July 14, 1949, looking south from the same point as in figure 6A and 6B.
(Photo Nos. 1949-129, E-7-1949)

Figure 6D.
August 27, 1985, looking south from same point as in figure 6A, 6B, and 6C.
(Photo No. 1985-129)

Figure 7A.
August 21, 1907, about 13 miles south of Burlington. (Photo No. F-10-1907)

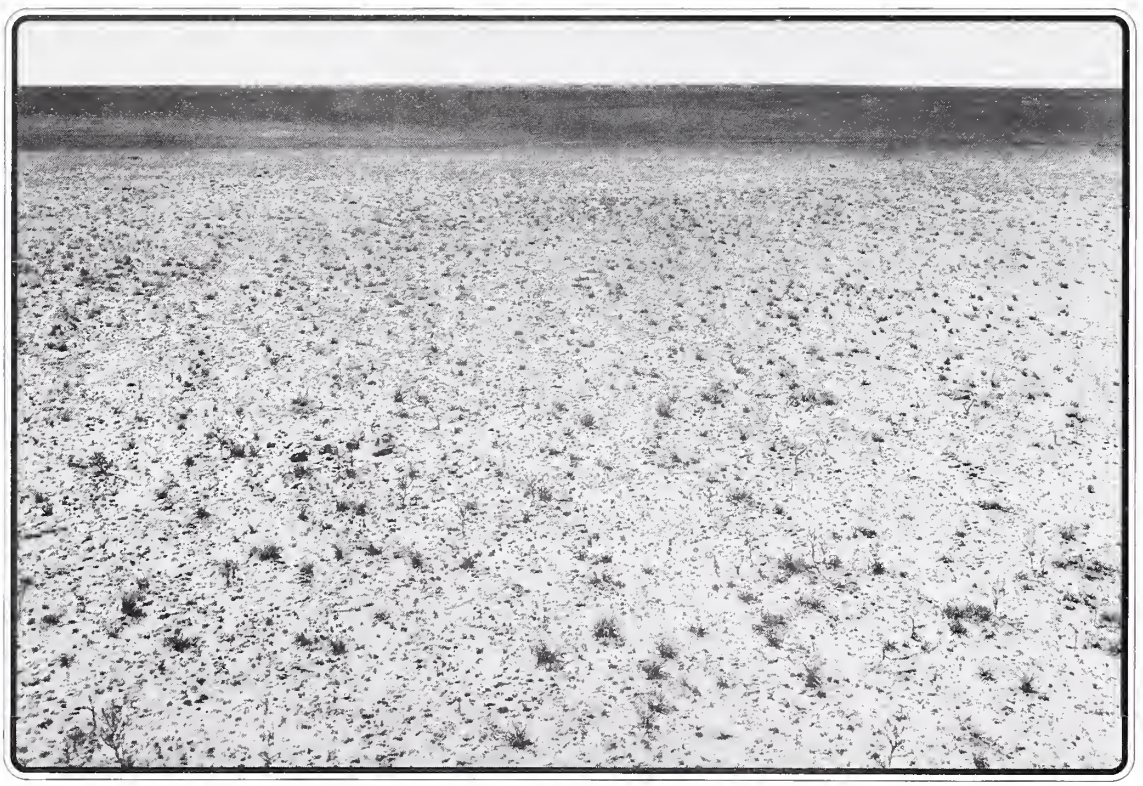


Figure 7B.
May 25, 1937, same location as that shown in figure 7A. (Photo No. G-9A-1937)

Near Sheridan Lake

In June 1940 near Sheridan Lake, the vegetation normally dominated by a dense stand of shortgrass was sparse and weedy as a result of drought (figure 8A). *Bouteloua gracilis* covered about 3 percent of the area, while *Buchloe dactyloides* was almost absent. In a detail photograph (figure 8B), *Salsola iberica* was the most conspicuous plant, but *Euphorbia serpyllifolia*, *Lepidium densiflorum*, *Lappula redowskii*, and *Cryptantha minima* were present. Where silt from adjacent cultivated fields had collected on the surface, *Salsola iberica* grew taller and formed a more dense cover that shows up as the darker areas in the photograph. The plants were badly wilted. In some places there were as many as 60 plants per square foot of *Lepidium densiflorum*, and each plant produces about 300 seeds, or about 18,000 seeds per square foot of surface.

In 1949 this area was in wheat, but the photograph shown in figure 8C was taken just north of the road in native shortgrass that had not been disturbed and was judged to be comparable to the site shown in figure 8A. The recovery of the shortgrass from drought was almost complete. The composition of the shortgrass was about 70 percent *Buchloe dactyloides* and 30 percent *Bouteloua gracilis*, as shown in figure 8D. This fine cover, about as dense as ever found on shortgrass land, had developed from a sparse cover in 9 years. There were also occasional *Opuntia polyacantha* and *Astragalus pectinatus*.

In 1953, a year of low precipitation, the shortgrass cover that was excellent in 1949 was now dry and appeared lifeless (figure 8E). An automobile driven across the area had crushed and powdered the plants in the track. The grass crowns were largely of *Bouteloua gracilis* and showed no growth (figure 8F). Much of the vegetation was composed of young, dried-up small *Salsola iberica*, which in the photograph look like grass plants. There was not enough soil moisture to enable the shortgrass to grow. Of the annuals, only *Salsola iberica* showed a rather even distribution, but none of the plants exceeded an inch or two in height and all were dying of drought. A few other plants were noted, including *Opuntia polyacantha*, occasional small *Sphaeralcea coccinea*, and *Haplopappus spinulosus*, and a few very small *Chenopodium album*. In 1953, insufficient growth was made to protect the soil; and both 1954 and 1955 were dry, hot years. When this site was visited in 1955, shortgrass was as badly damaged as in 1937.

When the Sheridan Lake site was visited in 1985, the almost totally depleted stand present in 1953 had been replaced by an excellent stand of *Bouteloua gracilis*, nearly the maximum density found in eastern Colorado (figure 8G and 8H). *Buchloe dactyloides* occured only as scattered plants. According to Howard Eidel, the owner of this land, the summer of 1985 was dry and vegetation suffered as a result. The *Bouteloua gracilis* was relatively short and showed no seedheads, but how much of its shortness was due to deficient precipitation and how much to grazing could not be readily determined. Despite both dryness and grazing, the *Bouteloua gracilis* was maintaining an excellent stand. The above sequence of photographs (1940, 1949, 1953, and 1985) demonstrates the dynamics of shortgrass vegetation and the resiliency of *Bouteloua gracilis* to climatic perturbations. Shortgrass can deteriorate rapidly during drought periods to an annual weed cover with few perennial grasses remaining, yet recover quickly during periods of favorable precipitation.

—*Astragalus mollissimus* (woolly loco)

Figure 8A.
June 14, 1940, about 0.5 mile north and west of Sheridan Lake (shown in the background). (Sec. 25, T18S, R44W; Photo No. A-8-1940)

Figure 8B.
July 14, 1940, detail of area shown in figure 8A. (Photo No. A-10-1940)

Figure 8C.
July 13, 1949, about 0.5 mile north and west of Sheridan Lake (shown in the background). Figure 8A, shows an area south of Colorado Highway 51, but the area was in wheat in 1949. Figure 8C through 8H shows a comparable nondisturbed shortgrass area located just north of the highway. (Sec. 24, T18S, R44W; Photo Nos. 1949-126, E-1-1949)

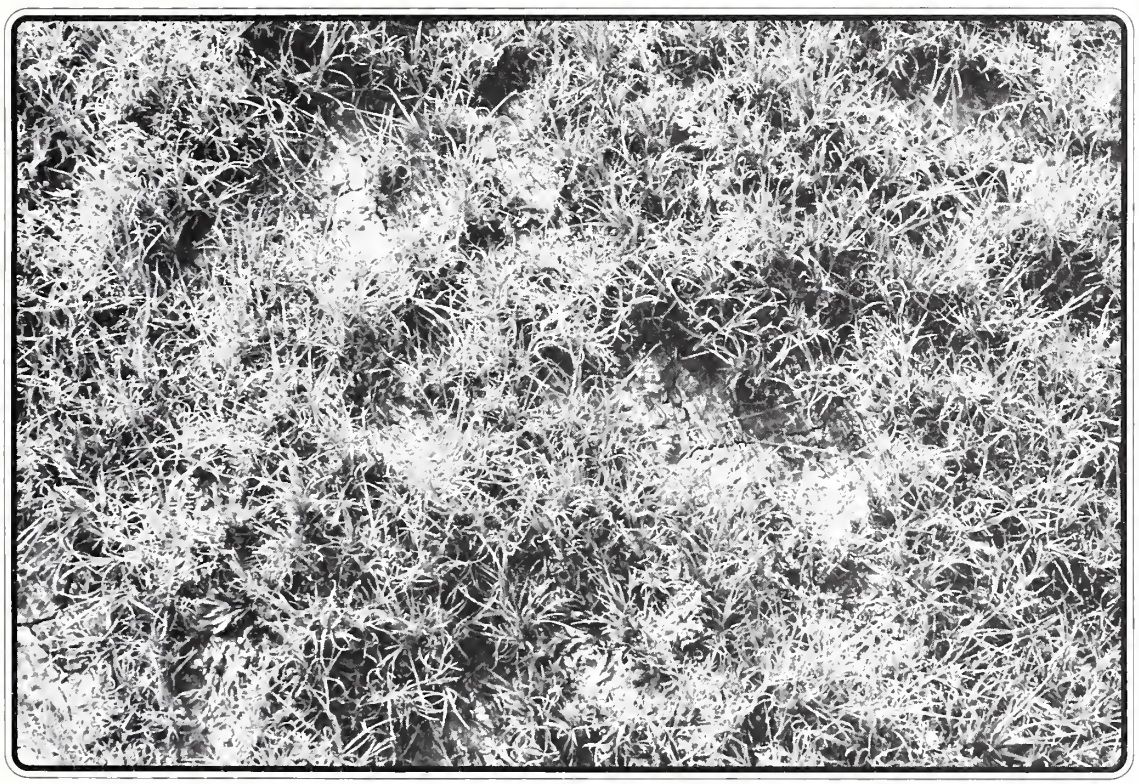


Figure 8D.
July 13, 1949, detail of area shown in figure 8C. (Photo Nos. 1949-127, E-3-1949)

Figure 8E.
June 30, 1953, same location as that shown in figure 8C. (Photo No. A-7-1953)

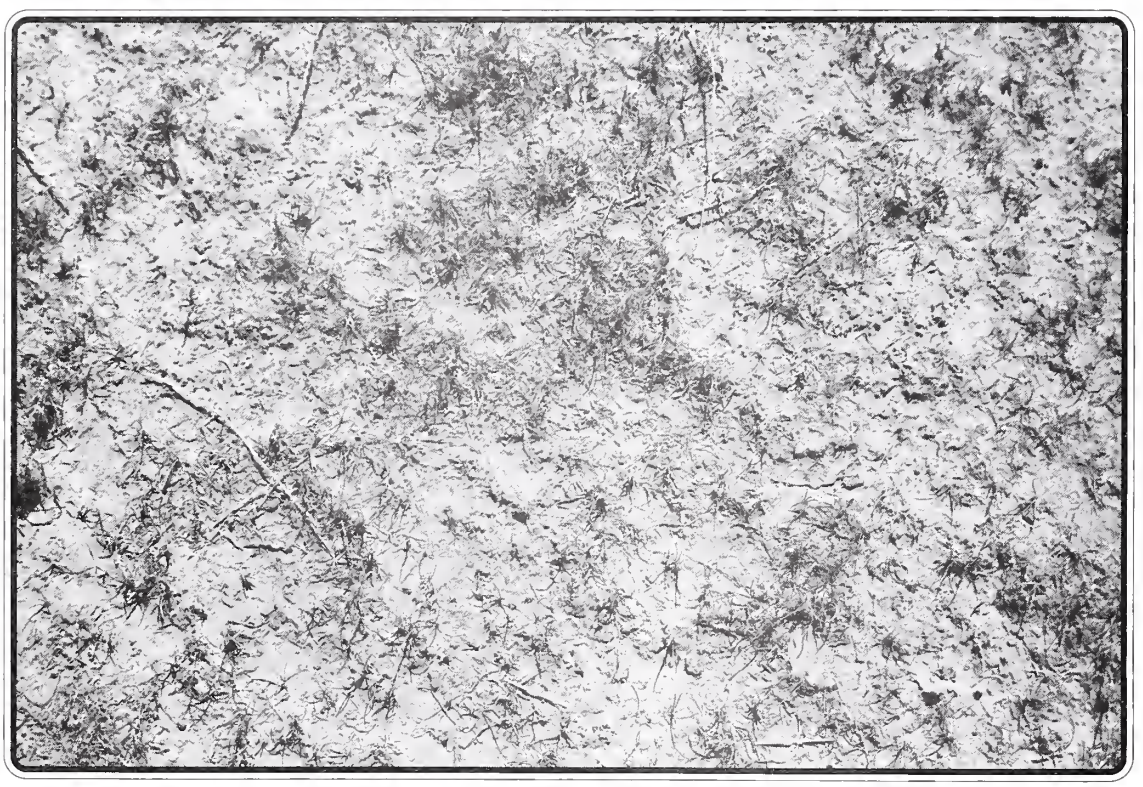


Figure 8F.
June 30, 1953, detail of figure 8E. (Photo No. A-9-1953)

Figure 8G.
August 28, 1985, same location as that shown in figure 8C and 8E. (Photo No. 1985-126)

Figure 8H.
August 28, 1985, detail of figure 8G. (Photo No. 1985-127)

South of Lamar

In 1937, J. T. Pruitt's farm, which was located south of Lamar and which previously had had a good shortgrass cover, showed only a few crowns of *Bouteloua gracilis* and *Buchloe dactyloides* (figure 9A). No green plants of any kind could be found. The farm, like most of the others in this vicinity, was covered with dust from the cultivated land on the west. Dust storms were so severe that according to Pruitt, jackrabbits totally blinded by dust could be readily caught. In 1949, the land had been plowed, so it was not possible to determine recovery from the drought. A new house had been built on the site (figure 9B). The site was covered with a dense stand that included *Melilotus officinalis*, *Chenopodium leptophyllum*, *Salvia reflexa*, *Aristida longiseta*, *Helianthus annuus*, and *Erigeron canadensis*. Trees around the house had made considerable growth. In 1985, the site continued to show signs of disturbance but did not appear to have been farmed within the last few years (figure 9C). The vegetation consisted of a moderately dense stand of *Bromus tectorum* and *Salsola iberica* but also contained scattered *Agropyron cristatum*, *Sporobolus cryptandrus*, *Tribulus terrestris*, *Kochia scoparia*, *Chloris virgata*, and *Eriogonum annuum*. The roadside had been seeded to *Agropyron cristatum*, but a poor stand resulted. Annual weeds and *Chloris virgata* were more common than *Agropyron cristatum*.

On a cultivated field 36.5 miles south of Lamar, photographed in May 1937 (figure 10A), the soil had piled up in small dunes wherever old crop plants or weeds had broken the clean sweep of the wind. Plants of *Salsola iberica* had partially held the soil and caused small loam dunes to form in the fields. Nearly all of the cultivated land in southeastern Colorado and southwestern Kansas was in this condition in 1937. Not a green plant was evident. The annual rainfall at Lamar from 1931 to 1937 averaged 10 inches, 5 inches below the long-time average.

In 1949, the land shown in figure 10A had been plowed and planted, but a few miles distant, at a point 29 miles south of Lamar, the native shortgrass had recovered (figure 10B). The shortgrass cover, mostly *Bouteloua gracilis* with some *Buchloe dactyloides*, was excellent. During the years of high precipitation, 1941 to 1949, rainfall averaged 18 inches. Revegetation on unplowed land was rapid during this wet period, and excellent stands of shortgrass developed in 9 years (see figures 6C, 8C, and 10B). On abandoned cultivated land the reestablishment of the shortgrass cover would require much longer.

A number of dry years after 1949 again reduced the shortgrass to an open, sparse cover. The area 29 miles south of Lamar, photographed in 1949, was photographed again in 1953 (figure 10C). The 1953 photograph was taken in the opposite direction to that of the 1949 view (figure 10B) to get back lighting to show detail. The excellent shortgrass cover of *Bouteloua gracilis* and *Buchloe dactyloides*, which had fully recovered during the years 1938-1949, had deteriorated into a spotty weed cover. There were areas of nearly pure shortgrass, mostly *Buchloe dactyloides*, with some *Bouteloua gracilis*; but many areas were badly damaged, having practically no grass and only a scattered weedy cover of severely wilted *Gutierrezia sarothrae*, *Chenopodium album*, *Salsola iberica*, *Sphaeralcea coccinea*, and *Sophora sericea*. Most of the plants appeared dead except *Gutierrezia sarothrae*, very small *Psoralea tenuiflora*, and an occasional *Chrysothamnus graveolens*.

When this site was visited in 1985, it was found that the area photographed in 1949 had been plowed, so an alternative area, 1.5 miles north and with very similar soil and topographic characteristics, was photographed (figure 10D). The vegetation was dominated by *Buchloe dactyloides* but included substantial *Bouteloua gracilis*, *Sporobolus cryptandrus*, and *Aristida longiseta*. Occasional plants of *Opuntia polyacantha*, *Gutierrezia sarothrae*, *Sphaeralcea coccinea*, *Chrysothamnus graveolens*, and *Yucca glauca* were observed. There were almost no annuals in the stand, and ground cover was about 60 percent. In this part of the State, native vegetation was still present in large acreages because the erratic rainfall makes crop production unpredictable. There were also large acreages of "go-back" land, where cultivation had been abandoned after the drought of the 1930's.

Figure 9A.
May 27, 1937, J. T. Pruitt's farm, 36.5 miles south of the Atchison, Topeka and Santa Fe Railroad tracks in Lamar. The borrow pit of the highway is in the foreground. (Photo No. H-1-1937)

Figure 9B.
July 13, 1949, same site as that shown in figure 9A. (Photo Nos. 1949-124, D-9-1949)

Figure 9C.
August 28, 1985, same site as that shown in figure 9A and 9B. Note how much the trees and shrubs had grown. (Photo No. 1985-124)

Figure 10A.
May 27, 1937, 36.5 miles south of Lamar. (Photo No. H-2-1937)

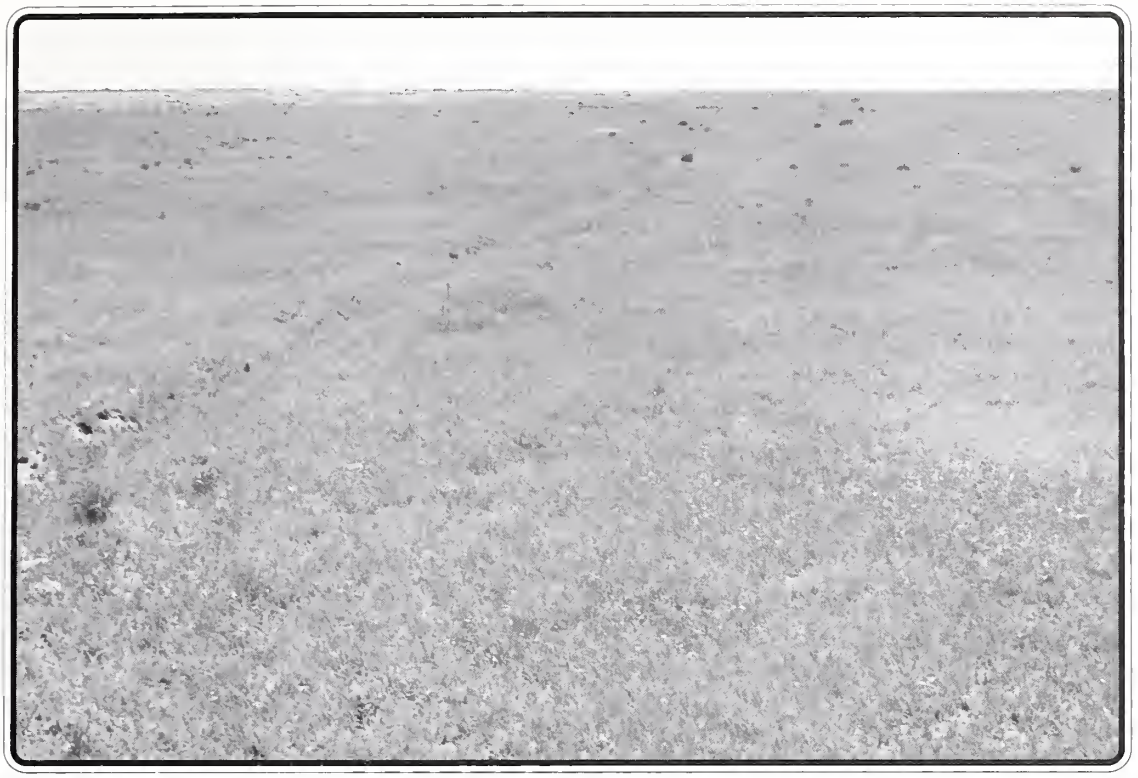


Figure 10B.
July 13, 1949, land similar to that shown in figure 10A (which had been plowed in 1949) but located 29 miles south of Lamar and still vegetated by native shortgrass. (Photo Nos. 1949-125, D-11-1949)

Figure 10C.
June 30, 1953, same area as that shown in figure 10B but taken in the opposite direction to show detail of shortgrass, which was very open and largely destroyed by drought. (Photo No. A-11-1953)

Figure 10D.
August 28, 1985, land similar to that shown in figure 10A, 10B, and 10C but located 28.7 miles south of the Atchison, Topeka and Santa Fe Railroad tracks in Lamar. (Photo No. 1985-125)

—*Sporobolus cryptandrus* (sand dropseed)

South of La Junta

Figure 11A shows the vegetation south of La Junta in 1907, and figure 11B the same area in 1949. In 1907 the area had an open cover occupying about 30 percent of the surface, typical of the vegetation on the limey soils of this area. The vegetation consisted of many species such as *Muhlenbergia torreyi*, *Linum rigidum*, *Lappula redowskii*, *Plantago patagonica*, *Hymenoxys acaulis*, *Artemisia bigelovii*, *Sphaeralcea coccinea*, *Bouteloua curtipendula*, *Orysopsis hymenoides*, *Cryptantha thyrsiflora*, *Hilaria jamesii*, and *Calylophus serrulata*. *Bouteloua gracilis* was the principal grass and *Gutierrezia sarothrae* was especially prominent. In 1949 *Bouteloua gracilis* formed an almost pure stand and *Gutierrezia sarothrae* had disappeared. New trees of *Populus sargentii* appeared along the wash in the background of the photo. The large trees (also *Populus sargentii*), prominent in 1907, had disappeared.

In general, the lime soils or outcrops of caliche-like material south of La Junta—dominated in 1907 by *Gutierrezia sarothrae*, *Artemisia bigelovii*, and a mixture of other plants—had developed a nearly pure cover of *Bouteloua gracilis* by 1949 after the relatively wet years 1941 to 1949. Other plants, although still present, were relatively unimportant. The more open cover on the crests in this vicinity had a much-improved plant cover in 1949. The more open shortgrass vegetation on lime outcrops did not deteriorate during the dry years as rapidly as did the well-sodded areas of shortgrass on relatively more productive loam soils and hence was in a condition to take advantage of the moist years.

When this area was visited in 1985, the exact camera point used previously could not be found, but the new point used is close (figure 11C). This area appeared to have been severely disturbed between 1949 and 1985. In 1985, vegetation was dominated by *Bouteloua gracilis*, *Buchloe dactyloides*, *Aristida longiseta*, *Salsola iberica*, and *Bromus tectorum* but also included some *Eurotia lanata*, *Hilaria jamesii*, and *Gutierrezia sarothrae*. The stand was generally poor and showed the effects of dryness and probably of past heavy grazing, although there was little apparent use in 1985. There again appeared to have been a loss of *Populus sargentii* trees in the background, and they had been replaced by new trees. The grass stand was in decidedly poorer condition than that shown in the 1949 photograph.

Figure 11A.
June 8, 1907, south of La Junta 2.4 miles from the intersection of Third and San Juan Streets. (Sec. 23. T24S. R55W; Photo No. 1907-13)

Figure 11B.
July 12, 1949, same location as that shown in figure 11A. (Photo Nos. 1949-122, D-6-1949)

Figure 11C.
August 28, 1985, approximately the same location as that shown in figures 11A and 11B. (Photo No. 1985-122)

Southeast of Clifford

A sharp ecotone between sandy and hard lands is shown in figure 12A, 12B, and 12C. These photographs were taken 2.5 miles southeast of Clifford, which is southeast of Hugo.

In 1907, the horses were at the edge of the sandy land (figure 12A). The foreground was adobe or hard land. The vegetation on the hard land was *Bouteloua gracilis, Sphaeralcea coccinea, Ratibida columnifera, Cirsium undulatum, Agropyron smithii, Baliia oppositifolia, Schedonnardus paniculatus*, and *Astragalus bisulcatus*. In the background on sandy land the vegetation was *Calamovilfa longifolia, Aristida longiseta, Andropogon hallii, Bouteloua gracilis, Artemisia filifolia, Thelesperma megapotanicum, Mentzelia nuda, Lithospermum incisum, Heliantlus petiolaris, Erigeron canadensis, Salsola iberica*, and *Ambrosia trifida*.

In 1949, (figure 12B) the foreground showed *Bonteloua gracilis, Psoralea tenuiflora, Aristida longiseta, Sphaeralcea coccinea, Cirsium undulatum, Agropyron smithii, Heterotheca villosa*, and *Artemisia ludoviciana*. The sandy land vegetation in the back was chiefly *Artemisia filifolia, Bontelona gracilis, Stipa comata, Heliantlus petiolaris, Calamovilfa longifolia*, and *Mentzelia nuda*. This entire area had been heavily grazed. The chief change from 1907 to 1949 on the adobe soil (foreground) was invasion of the rather dense stand of *Bouteloua gracilis* by *Aristida longiseta*, probably the result of overgrazing. In 1949 the sandy land was less dominated by *Calamovilfa longifolia* than in 1907; there were more *Bouteloua gracilis* and *Stipa comata* but practically no *Andropogon hallii*. The sharp ecotone between the grama-grass type and the sandhills-mixed type in the back was marked by the position of the horses in 1907 and by the car in 1949.

Vegetation on the hard land in the foreground in the 1985 photograph was predominantly *Bouteloua gracilis*, but it also included *Sporobolus cryptandrus, Agropyron smithii, Festuca octoflora, Lepidium densiflorum, Sphaeralcea coccinea, Aristida longiseta*, and *Ipomoea leptophylla* (figure 12C). The sandy land beyond the truck was dominated by *Artemisia filifolia, Bouteloua gracilis, Gutierrezia sarothrae, Sporobolus cryptandrus, Aristida longiseta, Stipa comata, Plantago patagonica, Sphaeralcea coccinea*, and *Grindelia squarrosa*. There was no *Calamovilfa longifolia* or *Andropogon hallii* on the sandy land. The area continued to be heavily grazed. In terms of species composition, the sandy land appeared to be suffering more from the loss of desirable species than the hard land. Although weedy and probably producing much less than its potential, the hard land was maintaining an effective shortgrass cover.

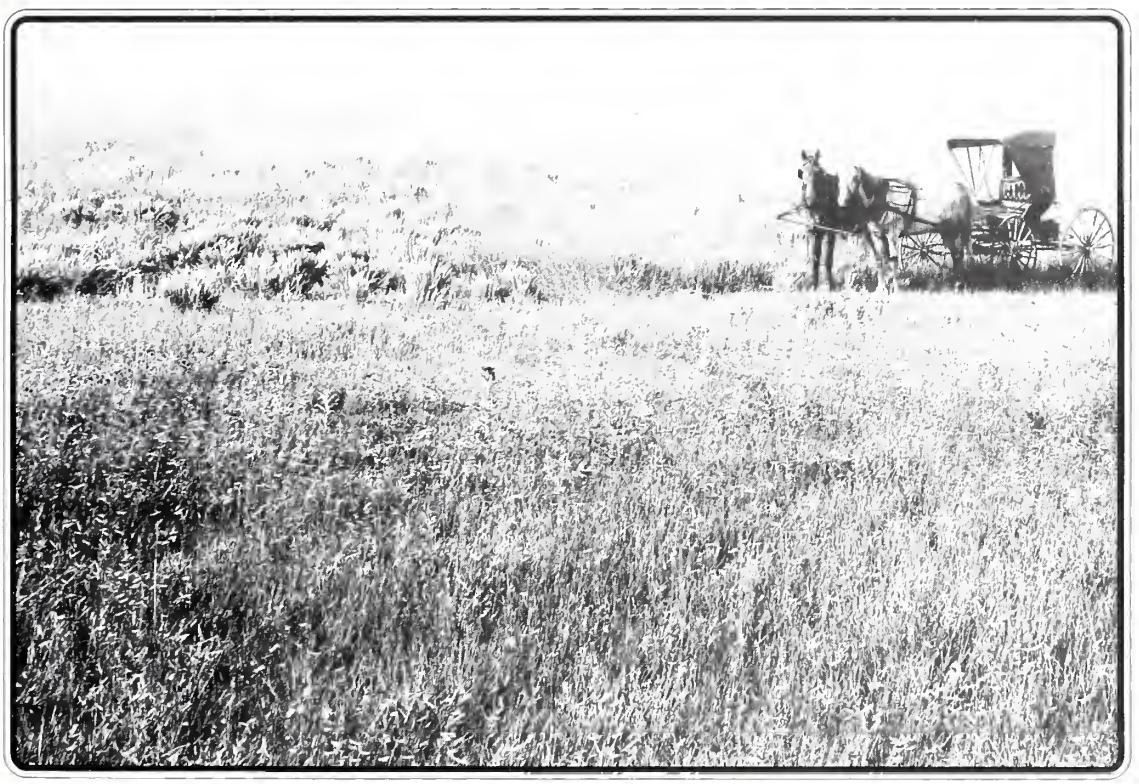


Figure 12A.
August 23, 1907, 2.5 miles southeast of Clifford (southeast of Hugo). (Sec. 16, T12S, R53W; Photo No. 1907-116)

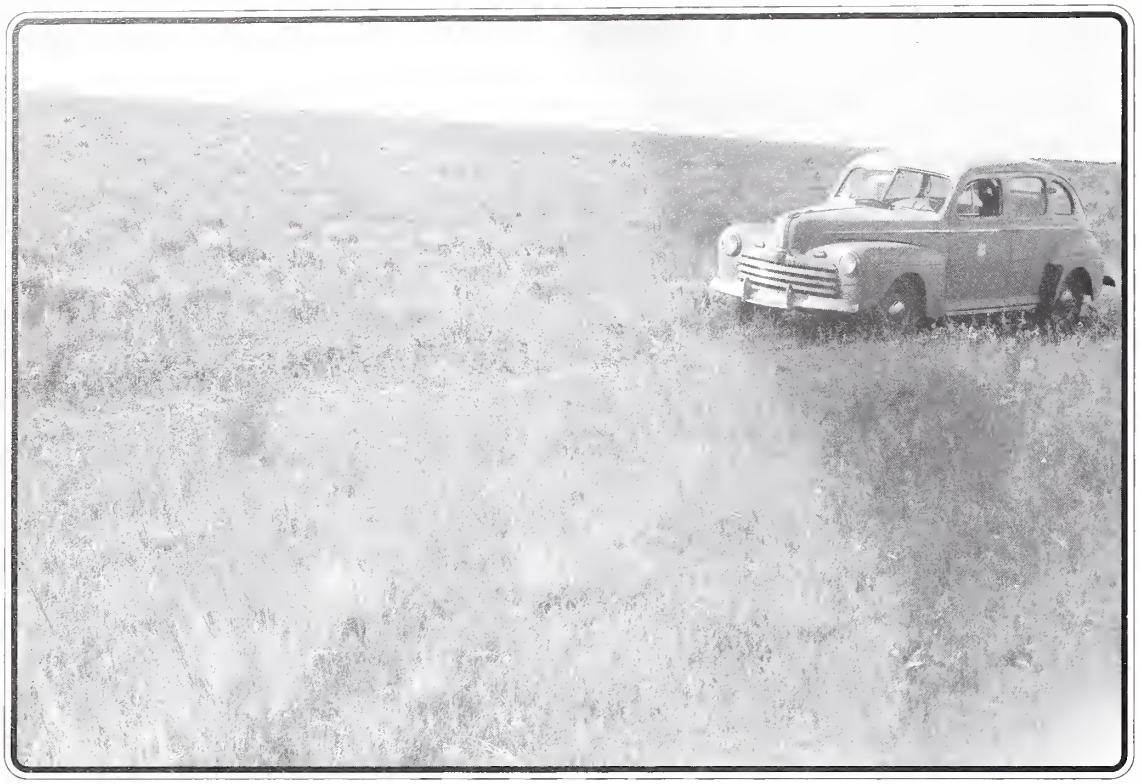


Figure 12B.
August 10, 1949, same location as that shown in figure 12A. (Photo Nos. 1949-256, AA-7-1949)

Figure 12C.
August 27, 1985, same location as that shown in figure 12A and 12B. (Photo No. 1985-256)

Clifford

Figure 13A shows a site 1.1 miles southeast of Clifford (called Mirage in 1907), which is southeast of Hugo. The foreground was open saline-alkali soil. Farther back, the soil was less alkaline. In 1907, the plant cover in the foreground was *Sporobolus airoides*, *Bouteloua gracilis*, *Chrysothamnus pulchellus*, *Schedonnardus paniculatus*, *Sphaeralcea coccinea*, and in places *Distichlis stricta*. *Sporobolus airoides* was the most abundant species in the foreground, but farther back *Bouteloua gracilis* dominated, along with some plants of *Aristida longiseta*. The claim shanty in the background had only recently been built.

In 1949 (figure 13B), *Sporobolus airoides* was the dominant, but *Bouteloua gracilis* was also very abundant. Other plants were *Distichlis stricta*, *Salsola iberica*, *Opuntia fragilis*, *Portulaca oleracea*, *Buchloe dactyloides*, *Kochia scoparia*, and *Bouteloua simplex*.

The principal grasses in 1985 were *Bouteloua gracilis* and *Sporobolus airoides* with some *Distichlis stricta* (figure 13C). There were occasional *Chrysothamnus pulchellus* and *Salsola iberica*. The area appeared to have been severely disturbed since the previous pictures had been taken. The poor growth of the vegetation is believed to have been a result of possible mechanical disturbance, heavy grazing, and low precipitation.

Before 1907, this part of Colorado was open land and subject to grazing at any time. Between 1907 and 1949, the land was homesteaded and control of use placed in the hands of local owners. The vegetation in 1907 was more heavily grazed than in 1949. Consequently, between 1907 and 1949, the plant cover increased greatly. In the background, the ranch headquarters had been developed. The vegetation deteriorated greatly between 1949 and 1985, but this is probably typical of what might be expected on heavily grazed or severely disturbed alkali soils.

Figure 13A.
August 23, 1907, 1.1 miles southeast of Clifford, southeast of Hugo. (Sec. 4, T12S, R53W; Photo No. 1907-117)

Figure 13B.
August 10, 1949, same location as that shown in figure 13A. (Photo No. 1949-258, AA-11-1949)

Figure 13C.
August 27, 1985, same location as that shown in figure 13A and 13B. (Photo No. 1985-258)

CHANGES IN WIREGRASS (*Aristida longiseta*) TYPE

Transition From Shortgrass to Wiregrass on the Wray Divide

As moisture conditions become more favorable (either as a result of more rainfall or, more commonly, deeper soil penetration by water) deeper rooted species, notably *Aristida longiseta*, become more abundant in the shortgrass cover. Shantz called such covers the "wiregrass type."[1] The wiregrass type typically consists of a more or less open cover of *Bouteloua gracilis* and *Buchloe dactyloides*, with a scattered overstory of *Aristida longiseta* and other deep-rooted species. It often appears as a belt between the shortgrass and bunchgrass (*Schizachyrium scoparium*) types. Conditions for crop production are more favorable on lands that support the wiregrass type than on lands that support the typical shortgrass type.

On the divide south of Wray, the shortgrass cover with many *Aristida longiseta*, *Psoralea tenuiflora* and *Psoralea lanceolata* was respresentative of the more productive shortgrass land in eastern Colorado in 1908 (figure 14A). In this area, the soil was a little deeper and the rainfall a little higher than at Akron. Because of more favorable growing conditions, the homesteaders did not fully desert this region during the drought period of 1892-1893.

In 1908 the vegetation three miles east of Vernon was similar to that on the divide south of Wray and was composed of shortgrasses with scattered *Aristida longiseta*, *Psoralea tenuiflora*, and *Psoralea lanceolata* (figure 15A). Also present at that time were *Agropyron smithii*, *Ratibida columnifera*, *Sphaeralcea coccinea*, *Oxybaphus linearis*, *Haplopappus spinulosus*, *Hymenoppapus filifolius*, *Opuntia polyacantha*, and *Stephanomeria tenuifolia*.

In 1937, after the dry, hot period beginning in 1931, the *Aristida longiseta* had disappeared, and even the shortgrasses were nearly destroyed (figures 14B, 15B). A native annual weed stage consisting of *Lappula redowskii*, *Lepidium densiflorum*, and *Chenopodium leptophyllum* had developed. The shortgrasses were scattered throughout, but in many of the weed patches (indicated by darker areas in figure 15B), they were represented only by inactive root crowns or stolons because almost everything above the soil had been eaten. Some sparse stands of *Bouteloua gracilis* and *Buchloe dactyloides* appear as lighter areas in the photograph. Note, however, that the foreground in figure 14B is outside the barbed wire fence, which paralleled a road. In this foreground the vegetation had been protected from grazing, and the shortgrasses were still in fair condition. *Helianthus annuus* was the common ruderal seen in the borrow pit. The point is that the deterioration shown in figures 14B and 15B resulted from the combined effects of drought and grazing. In the grazed fields, the plant cover consisted of annual weeds that were typical of much of eastern Colorado and western Nebraska and Kansas in 1937. Shantz' field notes at the time read:

> The great heritage of shortgrass on the hard land on this part of the High Plains has been overgrazed, trampled, and droughted out over great areas. The weed pastures, patches of *Lepidium densiflorum*, *Lappula redowskii*, *Plantago pantagonica*, and *Chenopodium leptophyllum* still have a plant or two of *Bouteloua gracilis* or *Buchloe dactyloides* which will rapidly recover if given a chance. So far the weeds are native weeds, hard-packed land weeds, which with the grass roots hold the soil in place. The dust comes from plowed land. Introduced weeds, such as *Salsola iberica* are mostly on cultivated land or on native sod covered with silt from cultivated fields. Probably the greatest need and best means of protection from wind erosion is to protect the last plants of *Bouteloua gracilis* and *Buchloe dactyloides*.

In 1940, after a wet, cool spring, the weeds were larger and more in evidence on the area east of Vernon than in 1937 (figure 15C). So green did the whole country look that many people thought the condition greatly improved. However, the shortgrasses showed little recovery. The plant cover was largely *Cryptantha minima*, *Salsola iberica*, *Lepidium densiflorum*, and *Plantago patagonica*. There were a few *Opuntia polyacantha*. *Bromus tectorum*, although noticeable along the Burlington Railroad, had not extended more than a mile or two south at that time.

Drought and heavy grazing deteriorated the vegetation in this wiregrass-shortgrass transition zone and produced stands similar to those of secondary succession on abandoned cropland. Consequently, the appearance of this vegetation in its deteriorated stage closely resembled intermediate to late stages of recovery from plowing, as shown, for example, in figure 16. This land near Yuma was plowed about 15 years before the photo was taken in 1907. *Gutierrezia sarothrae* made up about 60 percent of the vegetation, and *Buchloe dactyloides* about 40 percent. *Aristida longiseta*, *Schedonnardus paniculatus*, and *Bouteloua gracilis* were present.

In 1949, the fields shown in figure 15A, 15B, and 15C were in wheat, but a similar area is shown in figure 17. There was a good basal cover of *Bouteloua gracilis* and *Buchloe dactyloides*, over which taller plants of *Aristida*

[1]In Shantz' previous publications, the shortgrass type with an overstory of *Aristida longiseta*, which is found on sandy loam soils, is referred to as the "wiregrass type."

longiseta, *Psoralea tenuiflora*, and *Psoralea lanceolata* were prominent.

During the dry years prior to 1941, the deeper rooted *Aristida longiseta* and *Psoralea tenuiflora* were killed out by drought, and the persisting shortgrasses were badly damaged by overgrazing. As early as 1937, the vegetation had changed from a good wiregrass overstory to a nearly pure stand of shortgrasses, and in some areas continued heavy grazing caused a near annual weed stage to develop. Then the vegetation recovered, passing through a rather luxuriant weed stage followed by increase of the shortgrasses and, finally as a result of cool, wet years of the 1940's, reappearance of *Aristida longiseta* and *Psoralea tenuiflora*. During the years with only shortgrasses or annual weeds, moisture penetration was shallow; but during years such as 1941 to 1949, with the exception of 1943, water percolated to the deeper soil layers, so established *Aristida longiseta* and *Psoralea tenuiflora* found conditions favorable for growth.

Figure 14A.
July 10, 1908, wiregrass type between Wray and Vernon. (Photo No. F-10-1908)

—*Bromus tectorum* (downy brome)

Figure 14B.
May 24, 1937, same location as that shown in figure 14A. (Photo No. E-11-1937)

Figure 15A.
July 10, 1908, wiregrass type 3 miles east of Vernon. (Photo No. D-1-1908)

Figure 15B.
May 28, 1937, same location as that shown in figure 15A. (Photo No. F-1-1937)

Figure 15C.
June 15, 1940, same location as that shown in figure 15A and 15B. (Photo No. C-7-1940)

Figure 16.
July 8, 1907, 1 mile south of Yuma. (Photo No. 1907-43)

Figure 17.
August 16, 1949, 1.25 miles east of Vernon. (Photo No. GG-2-1949)

Typical Wiregrass Type During Wet and Dry Periods

South of Yuma in 1910 in another typical wiregrass area, a nearly continuous cover of *Bouteloua gracilis* was present with the taller *Aristida longiseta* and *Psoralea tenuiflora* rather evenly scattered (figure 18A). The light silvery color of the mature *Aristida longiseta* contrasted sharply with the green plants of *Psoralea tenuiflora* and the green or straw-colored shortgrass. The wiregrass type occupied most of the sandy loam land. Many other plants, such as *Bouteloua hirsuta, Ipomoea leptophylla, Hymenopappus filifolius, Sphaeralcea coccinea, Ratibida columnifera, Haplopappus spinulosus, Heterotheca villosa, Eriogonum effusum, Liatris punctata,* Thelesperma *megapotamicum, Stipa comata, Carex stenophylla, Erysimum asperum, Festuca octoflora,* and *Erigeron canadensis,* increased. During the dry, hot period 1931 to 1937, *Psoralea tenuiflora, Aristida longiseta,* and other plants characteristic of the wiregrass type were killed by drought; and by 1937 only *Bouteloua gracilis* and *Buchloe dactyloides* still survived, although reduced to a very open stand (figure 18B).

During the wet years of 1941 to 1949, the shortgrasses reestablished (figure 18C). *Bouteloua gracilis* and *Buchloe dactyloides* were about equally dense. *Aristida longiseta* and *Psoralea tenuiflora* had entered the stand but were too small to show in the photograph. In the more open areas *Erigeron canadensis* was abundant.

According to Shantz' field notes when he reexamined this area on June 27, 1953, all the gains made in 1941 to 1949 had again been lost. The *Bouteloua gracilis* and *Buchloe dactyloides* were dry and had been grazed to the ground. The sparse cover of annual weeds included *Plantago patagonica, Cryptantha crassisepala, Lepidium densiflorum, Hordeum pusillum,* and an occasional *Bromus tectorum*. The whole area was straw colored due largely to *Hordeum pusillum*. There was an occasional very small *Psoralea tenuiflora* and a few *Opuntia polyacantha*.

When this area was visited in 1985, the field had been plowed and a center-pivot irrigation system installed. Therefore, the area directly across the highway to the west was photographed (figure 18D). Both the earlier photographs and the 1985 photograph were of sites located on a Haxtun sandy loam. The 1985 site was dominated by a poor stand of *Bouteloua gracilis*, but *Stipa comata, Aristida longiseta, Petalostemon purpureum, Psoralea tenuiflora*, and some *Opuntia polyacantha* were also present, with a thin overstory of *Artemisia filifolia. Festuca octoflora* was abundant, most of it growing in clumps of *Bouteloua gracilis*. Having recently suffered dieback, *Bouteloua gracilis* represented only about 10 percent of the ground cover. Some year in the recent past was apparently very dry at this particular site.

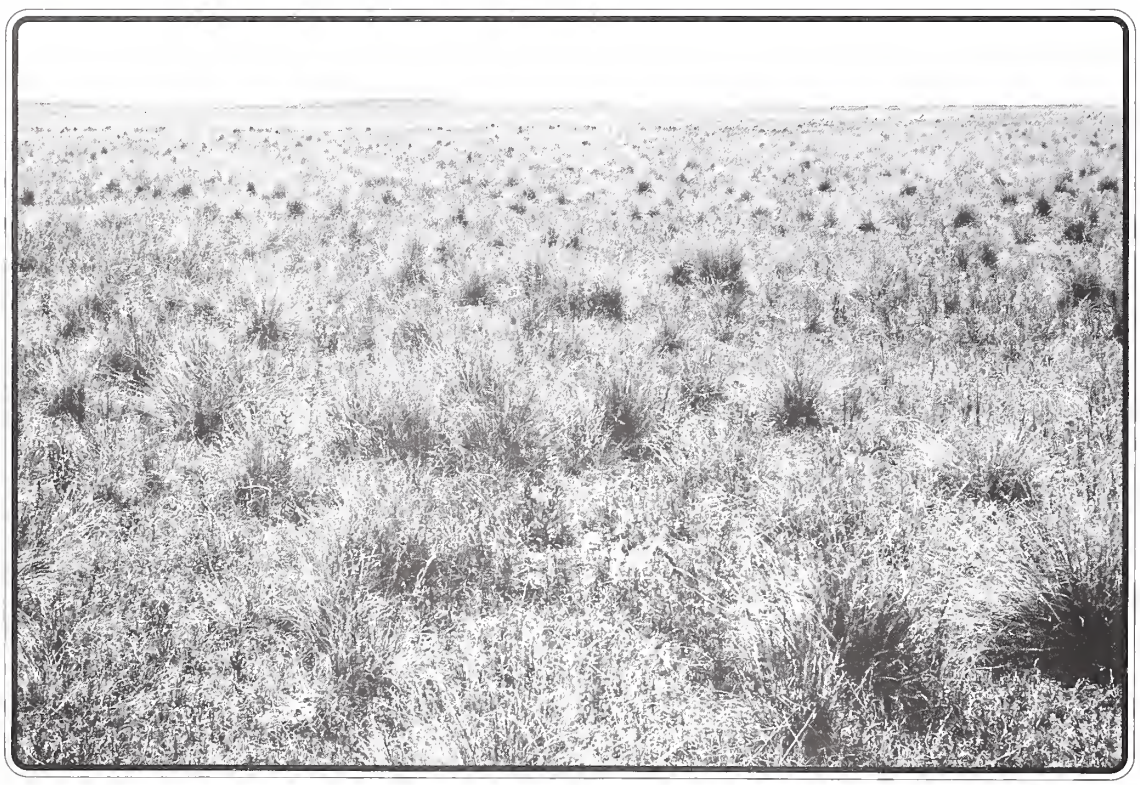


Figure 18A.
June 17, 1910, 4.5 miles south of Yuma on Highway No. 59, looking east from highway.
(Sec. 14, T1N, R48W; Photo No. C-4-1910)

Figure 18B.
September 18, 1937, same location as figure 18A. (Photo No. M-12-1937)

Figure 18C.
August 16, 1949, same location as figure 18A and 18B. (Photo Nos. 1949-285, FF-8-1949)

Figure 18D.
July 16, 1985, 4.5 miles south of Yuma on Highway 59, looking west from west of highway. (Sec. 15, T1N, R48W; Photo No. 1985-285)

—*Hordeum pusillum* (little barley)

Revegetation on Wiregrass Land Following Plowing

Figure 19A, taken in 1908, shows a blowout that had developed in wiregrass type land that had been plowed and planted to trees (*Acer saccharinum*). A few of the trees persisted. Open sand had been invaded by *Refieldia flexuosa* and *Psoralea lanceolata*. The edges of the blowout were covered with *Cenchrus pauciflorus*, and the inner portion next to the bare sand had an open stand of *Redfieldia flexuosa*, either pure or in close association with *Psoralea lanceolata*. There was no *Muhlenbergia pungens*. On the more stable soil in the foreground, *Psoralea lanceolata* was most abundant in a stand that included *Cenchrus pauciflorus*, *Redfieldia flexuosa*, *Artemisia filifolia*, and *Amaranthus powellii*.

The *Aristida longiseta* community in the area surrounding this wind-eroded field in 1908 had an understory of mostly *Bouteloua gracilis*, intermixed with *Aristida longiseta*, *Stipa comata*, *Heterotheca villosa*, *Haplopappus spinulosus*, *Artemisia filifolia*, *Psoralea tenuiflora*, *Sporobolus cryptandrus*, *Ipomoea leptophylla*, *Artemisia frigida*, *Liatris punctata*, and many other plants.

The plant cover in 1937 was mostly *Bouteloua gracilis*, with *Aristida longiseta*; considerable *Artemisia frigida*, *Artemisia filifolia*, *Sporobolus cryptandrus*, *Plantago patagonica*, and *Psoralea lanceolata*; and a few *Cenchrus pauciflorus*, *Redfieldia flexuosa*, *Haplopappus spinulosus*, and *Amaranthus powellii* (figure 19B). In 29 years, ending with the dry, hot period 1931-1937, the open sandy area shown in figure 19A developed a nearly typical wiregrass cover. Almost all other blowouts in this general area were covered and held by *Muhlenbergia pungens* during the hot, dry period 1931 to 1937, and perhaps its absence from this particular area permitted the more normal reestablishment of the wiregrass type. It was not possible to follow subsequent developments on this area because in 1949 it had become the Yuma city dump.

Figure 19A.
August 29, 1908, 3 miles east of Yuma. (Photo No. 0-5-1908)

Figure 19B.
September 12, 1937, same location as figure 19A. (Photo No. L-11-1937)

—*Redfieldia flexuosa* (blowout grass)

CHANGES IN BUNCHGRASS (*Schizachyrium scoparium*) TYPES

Transition From Shortgrass to Bunchgrass South of Vernon

South of Vernon and a little east of Highway 385 is an area of gently sloping hills. In 1907, shortgrasses, with a few *Aristida longiseta* and *Psoralea tenuiflora*, occupied the slopes below the crests where a loam soil had developed (figure 20A). *Gutierrezia sarothrae*, *Sphaeralcea coccinea*, *Haplopappus spinulosus*, *Opuntia polyacantha*, and *Ratibida columnifera*, which were characteristic of shortgrass vegetation, were also present. *Schizachyrium scoparium* was dominant on the less stable soil of the ridges and alternated sharply with the shortgrasses on the slopes. *Bouteloua hirsuta*, *Dalea enneandra*, *Polygala alba*, *Bouteloua curtipendula*, *Linum rigidum*, *Petalostemon oligophyllus*, and *Liatris punctata* also were found on the ridges.

In 1940 the same area showed only shortgrass vegetation (figure 20B). No trace could be found of *Schizachyrium scoparium* or of many of the associated species. The bunchgrass vegetation had been entirely killed out during the dry, hot years 1931-1940 and was replaced by shortgrass vegetation. The amount of grazing in this area is not known but was probably sufficient to partly account for the loss of *Schizachyrium scoparium*. The shortgrasses were entirely inactive and were represented by only small sod pieces with little leafage. The ground cover consisted largely of annual weeds. A few scattered clumps of *Opuntia polyacantha* were noticeable along with rather abundant but small annual weeds such as *Ledpidium densiflorum*, *Lappula redowskii*, *Cryptantha crassisepala*, *Salsola iberica*, and *Helianthus annuus*. In other parts of eastern Colorado, particularly on loamy plains sites, this species had spread to occupy large areas.

No detailed location descriptions were found of the area photographed in 1907 and 1940. In 1985, the same site or one very similar to the site photographed earlier was found 1.2 miles south of Vernon (figure 20C). In 1985, no *Schizachyrium scoparium* could be found. The area was covered by a dense stand of *Bouteloua gracilis* that included scattered *Agropyron smithii*, *Sporobolus cryptandrus*, *Aristida longiseta*, *Buchloe dactyloides*, *Schedonnardus paniculatus*, *Gutierrezia sarothrae*, *Psoralea lanceolata*, *Stipa comata*, *Bromus tectorum*, and *Opuntia polyacantha*. The area was heavily grazed, but the ground cover, including standing dead material, exceeded 60 percent. This site possibly had been plowed at some time in the past, but the possiblity could not be confirmed. The dense and vigorous stand of vegetation showed that this range site should be highly productive in years with average or above average precipitation.

Figure 20A.
August 11, 1907, south of Vernon on the breaks. (Photo No. 1907-87)

Figure 20B.
June 25, 1940, same location as that shown in figure 20A. (Photo No. C-10-1940)

Figure 20C.
July 31, 1985, 1.2 miles south of Vernon, nearly the same or possibly the same location as that shown in figure 20A and 20B (no precise description of the location could be found). (NW 1/4, Sec. 33, T1S, R44W; Photo No. C-10-1985)

Beecher Island

In 1914 the vegetation south of Beecher Island on the north-facing slope above the Arickaree River was mostly *Bouteloua gracilis* with small amounts of *Buchloe dactyloides, Artistida longiseta, Koeleria cristata, Sphaeralcea coccinea, Calylophus serrulata, Stephanomeria tenuifolia,* and many other plants common to the shortgrass type. The road in use in 1914 shows plainly in figure 21A. Some time before 1949, the old road was replaced by a new highway that shows in the 1985 photograph (figure 21B). The 1949 photograph is not suitable for reproduction and is not included here. By 1949, the foreground had been plowed and abandoned and the plant cover was *Schedonnardus paniculatus, Aristida longiseta, Sporobolus cryptandrus, Schizachyrium scoparium, Bouteloua gracilis, Dalea enneandra,* and *Bouteloua curtipendula.* Vegetation on the old road was mostly *Helianthus petiolaris, Petalostemon oligophyllus, Aster ericoides, Sphaeralcea coccinea, Gutierrezia sarothrae, Senecio mutabilis,* and *Oxytropis lambertii.* The *Populus sargentii* trees prominently marking the Arickaree River in the 1985 photograph were not prominent in 1914 but were in the 1949 photograph.

In 1985 (figure 21B), the foreground vegetation was much changed from that present in 1949. The foreground vegetation was dominated by *Schizachyrium scoparium, Bouteloua gracilis, Stipa comata, Aristida longiseta,* and *Bouteloua curtipendula.* The area on the near side of the fence showed little or no grazing, while the area beyond the fence was grazed. Vegetation on the abandoned road beyond the fence was mostly *Bouteloua gracilis, Bromus tectorum, Gutierrezia sarothrae,* and *Yucca glauca,* but on the near side of the fence the vegetation on the old road was mostly *Schizachyrium scoparium,* with some *Stipa comata,* and included few weeds or other species. The big difference between the grazed and ungrazed areas was the dominance of *Schizachyrium scoparium* in the ungrazed area. The vegetation beyond the fence was among the most productive in Yuma County, indicating what can be expected on north-facing slopes in the upland break sites of this area when heavy grazing is not a factor.

Figure 21A.
June 19, 1914, 1.8 miles south of Arickaree River, south of Beecher Island, west of Highway No. 53, camera facing north. (Sec. 28, T2S, R43W; Photo No. E-11-1914)

Figure 21B.
July 31, 1985, same location as that shown in figure 21A. (Photo No. 1985-263)

—*Bouteloua curtipendula* (sideoats grama)

Effects of Grazing and Moisture

The combined effects of grazing and moisture conditions on a *Schizachyrium scoparium* community in eastern Colorado are brought out in figure 22A, 22B, and 22C. In 1908 this field was in *Schizachyrium scoparium*. Some time after the road was built, *Schizachyrium scoparium* extended through the fence into the borrow pit. *Andropogon gerardii*, *Sorghastrum nutans*, and *Panicum virgatum* were scattered through the stand.

The decade preceding 1940 was generally hot and dry, and at nearby locations with weather conditions similar to those at the photographed site, *Schizachyrium scoparium* decreased. But at the photographed site (figure 22A), this species maintained an excellent stand along the road where it was protected from grazing and received runoff water from the road. In the fenced field, *Artemisia filifolia* and *Bouteloua gracilis* were dominant. The field also included *Bouteloua hirsuta*, *Bouteloua curtipendula*, *Calamovilfa longifolia*, *Aristida longiseta*, *Psoralea tenuiflora*, and many weedy annuals, such as *Plantago patagonica*, *Cycloloma atriplicifolium*, *Chenopodium leptophyllum*, *Lepidium densiflorum*, *Cryptantha crassisepala*, and *Salsola iberica*.

A photograph taken in 1949 (figure 22B) indicated that, during the cool, wet years 1941-1949, the vegetation in the field changed very little. Both *Artemisia filifolia* and *Bouteloua gracilis* had increased, and weeds, especially *Erigeron canadensis*, were abundant. There was no *Schizachyrium scoparium* in the field, but this species was still dominant in the borrow pit.

In 1953, (figure 22C) the vigor of *Bouteloua gracilis* in the field was reduced due to drought and also probably to grazing. The *Artemisia filifolia* was older and in decline. There were some *Psoralea tenuiflora*, *Cirsium plattense*, and *Ratibida columnifera*, and an occasional small *Schizachyrium scoparium*. The cover was open and included many annuals. Along the road, after the hot, dry years 1950-1953, *Schizachyrium scoparium* was nearly gone.

The sample outside the fence is not adequate for an indisputable comparison, but it does suggest that in Colorado, *Schizachyrium scoparium* is better able to survive in areas that are not heavily grazed and that are periodically flooded. Grazing and flooding would not necessarily be factors in the survivability of this species in areas with more favorable soil and moisture conditions such as those found in Kansas and Nebraska.

By 1985 the fence had been removed and the field plowed to the edge of the road. The borrow pit on the north side of the road had been disturbed by construction of a gas pipeline, precluding further photographic records.

Figure 22A.
June 5, 1940, 5 miles and five fenceposts west of Vernon, looking a little south of west.
(Sec. 28, T1S, R45W; Photo No. C-12-1940)

Figure 22B.
August 13, 1949, same location as that shown in figure 22A. (Photo No. 1949-266, CC-4-1949)

Figure 22C.
June 29, 1953, same location as that shown in figure 22A and 22B. (Photo No. A-4-1953)

CHANGES ON THE MORE STABLE COLORADO SANDHILLS

Yuma County

In 1908 *Schizachyrium scoparium* represented the most extensive plant community on the sandhills of eastern Colorado. Over great areas the bunches of *Schizachyrium scoparium* formed an almost solid stand, as shown in figure 23A. The characteristic reddish-brown color made *Schizachyrium scoparium* recognizable at great distances. Often the bunches were some distance apart and the interspaces were occupied by *Bouteloua hirsuta, Andropogon hallii, Calamovilfa longifolia, Aristida longiseta, Psoralea tenuiflora, Bouteloua gracilis, Artemisia filifolia,* and in more favorable places *Panicum virgatum* and *Sorghastrum nutans.*

In this same area in 1949 (figure 23B), the *Schizachyrium scoparium* had mostly disappeared. Annual weeds were more prominent than grasses. The prominent perennials were *Bouteloua gracilis, Calamovilfa longifolia, Bouteloua curtipendula, Artemisia filifolia, Stipa comata, Aristida longiseta, Andropogon gerardii,* and *Psoralea tenuiflora.*

In 1985, almost no *Artemisia filifolia* was present, although many old dead stems lay on the ground (figure 23C). Victor Pariset, the landowner, said that a severe hailstorm several years ago had broken down all the sagebrush on the site. No *Schizachyrium scoparium* was present. Instead, the area was covered by a dense stand of *Stipa comata,* with occasional plants of *Bouteloua gracilis, Calamovilfa longifolia,* and *Artemisia filifolia.* The soil where the photograph was taken is a Valent sand. Less than 0.25 mile to the east, the soil is a Manter loamy sand. The dividing line between the two soils is sharp. On the Manter soil, *Schizachyrium scoparium* was found and sometimes dominated the vegetation. *Schizachyrium scoparium* had been able to survive on the loamy sand but was unable to persist on the almost pure Valent sand.

An excellent *Schizachyrium scoparium* community, characteristic of much of the sandhills area, is shown in figure 24A, as photographed on August 17, 1915. With it were a few *Artemisia ludoviciana, Thelesperma megapotamicum, Evolvulus nuttallianus, Ambrosia psilostachya, Eriogonum annuum, Bouteloua hirsuta, Andropogon gerardii, Calamovilfa longifolia, Aristida longiseta, Psoralea tenuiflora, Artemisia filifolia,* and *Bouteloua gracilis.* The *Schizachyrium scoparium* was reddish, with bunches close enough together in most places to make it appear a nearly solid stand. However, in some places the soil was not completely covered, as would be typical of a true bunchgrass type, and then many other normally inconspicuous plants were noted.

In 1940, the *Schizachyrium scoparium* was entirely gone, as shown in figure 24B. Almost the whole area was in this condition. The old crowns of *Schizachyrium scoparium,* still in place, had extended a mass of roots deep into the soil. These crowns, although dead, still held the soil from blowing. The scattered living plants were *Bouteloua gracilis* and *Artemisia filifolia.* Much of the plant cover was of annual weeds such as *Lepidium densiflorum, Plantago patagonica, Cryptantha crassisepala,* and *Lappula redowskii.* A note written at this site in 1940 by Shantz states:

> Practically all of the country is under weeds, but *Bouteloua gracilis* forms a fairly good base under *Lepidium densiflorum* and much less under *Cryptantha.* Occasionally *Plantago patagonica* gives color and cover to the land. *Andropogon scoparius* [*Schizachyrium scoparium*] is gone [on this site]. Only along roads and in places where soil moisture is unusually favorable do you find any *Andropogon gerardii* or *Panicum virgatum.* [*Schizachyrium scoparium*] is rare, just occasional plants where soil moisture was available. I doubt if in two days and the trip between Yuma and Vernon more than a hundred plants have been seen. Much of the area is as shown in this photograph [figure 24B].

The pure stand of *Schizachyrium scoparium* shown in figure 24A, which had withstood grazing during favorable years, disappeared almost entirely during the hot, dry years 1931-1940, when it was also subjected to heavy grazing. By 1949 (no photograph available) it had largely been replaced by *Bouteloua gracilis,* with many annuals such as *Chenopodium leptophyllum* and *Erigeron canadensis* and perennials such as *Artemisia filifolia, Calamovilfa longifolia,* and *Andropogon gerardii.* The vegetation changed from *Schizachyrium scoparium* in 1908 to a weedy shortgrass in 1940 (figure 24B), and in 1949 to a sandhills-mixed type. Photographs for 1949 and 1985 are not available.

On June 18, 1940, an area that was adjacent to the one shown in figure 23A and that had supported a fine stand of *Schizachyrium scoparium* in 1915 now had a scattered cover of *Artemisia filifolia,* with *Bouteloua gracilis* between the bunches and dead crowns of *Schizachyrium scoparium* (figure 25A). There were a few *Agropyron smithii, Stipa comata, Calamovilfa longifolia, Aristida longiseta,* and *Bouteloua hirsuta.* There were many annual weeds such as *Plantago patagonica* and in many places *Cycloloma atriplicifolium, Lepidium densiflorum, Cryptantha crassisepala, Lappula redowskii,* and *Chenopodium leptophyllum.*

Nine years later (1949) the area showed a great increase of *Artemisia filifolia,* many of which were old and some of which were dying (figure 25B). Between

these plants the ground cover was largely *Bouteloua gracilis* and rarely included *Schizachyrium scoparium*, *Calamovilfa longifolia*, *Bouteloua hirsuta*, *Bouteloua curipendula*, *Stipa comata*, *Aristida longiseta*, *Psoralea tenuiflora*, *Andropogon gerardii*, *Erigeron canadensis*, *Croton texensis*, and *Cyperus filiculmis*.

In 1986, the *Artemisia filifolia* was largely gone, reportedly destroyed by a severe hailstorm several years previously (figure 25C). The dominant species was *Stipa comata*, with some *Bouteloua gracilis*, *Calamovilfa longifolia*, and *Artemisia filifolia*. This area was producing an excellent stand of grass, but none of the previously reported *Schizachyrium scoparium* was present.

Figure 23A.
September 12, 1908, sandhills west of Vernon and southeast of Yuma, a little northwest of the center of the section. (Sec. 11, T1S, R46W; Photo No. P-7-1908)

—*Andropogon hallii* (sand bluestem)

Figure 23B.
July 30, 1949, same location as that shown in figure 23A. The car was at the same location where the team stood in 1908. (Photo Nos. 1949-192, P-7-1949)

Figure 23C.
July 17, 1985, same location as that shown in figure 23A and 23B. Truck is about where the horses stood in figure 23A. (Photo No. 1985-192)

Figure 24A.
August 17, 1915, sandhills west of Vernon and southeast of Yuma. (Photo No. Y-5-1915)

Figure 24B.
June 12, 1940, same location as that shown in figure 24A. (Photo No. A-5-1940)

Figure 25A.
June 15, 1940, sandhills west of Vernon and southeast of Yuma, about 300 yards southwest of location shown in figure 23A. (Sec. 11, T1S, R46W; Photo No. D-5-1940)

Figure 25B.
July 30, 1949, same location as that shown in figure 25A. (Photo Nos. 1949-193, P-11-1949)

Figure 25C.
August 13, 1986, same location as that shown in figure 25A and 25B.
(Photo No. 1986-193)

—*Panicum virgatum* (switchgrass)

South of Las Animas

A strip of very sandy soils (Psamments) 3 to 4 miles wide follows along the south side of the Arkansas River from the Kansas State line westward to a point just south of Las Animas. The vegetation on this strip is similar to that on the sandy lands in the central and northern parts of Colorado.

A photograph taken in 1907 at the extreme western end of this strip of sandy soils (figure 26A) shows invasion of the open sand by *Artemisia filifolia* and *Yucca glauca*. Farther back the cover of 10 to 20 percent was composed of *Artemisia filifolia, Bonteloua gracilis*, and *Muhlenbergia torreyi*. Also present were *Bouteloua curtipendula, Splaeralcea coccinea, Gaura coccinea, Oenothera albicaulis*, and annuals, including *Euphorbia serpyllifolia, Festuca octoflora, Salsola iberica, Plantago patagonica*, and *Evolvulus nuttallianus*.

In 1949, the open sand shown in 1907 had a cover of *Artemisia filifolia* (figure 26B). Most of the plants were from 8 to 10 years old, but a few were older. Important species were *Andropogon hallii, Oryzopsis hymenoides, Sporobolus cryptandrus, Schizachyrium scoparium*, and in the more open area *Aristida longiseta* and *Mentzelia nuda*. Most noticeable was the absence of *Redfieldia flexuosa, Psoralea lanceolata, Muhlenbergia pungens*, and *Calamovilfa longifolia*, so common in many blowouts farther north. Most of the sandy land in this vicinity, south of Las Animas, had been leveled and irrigated.

In 1985, this area was drastically changed from what it had been in 1949 (figure 26C). The area was dominated by *Artemisia filifolia, Mentzelia nuda*, and *Salsola iberica*. A few *Kochia scoparia* and *Eriogonum annuum* were also present. A few *Sporobolus cryptandrus* were found after a walk of several hundred yards, but there was no evidence at all of the amount of grass reported in 1949. The entire area was heavily infested with pocket gophers, and the ground was largely covered by their mounds, a disturbance probably responsible for the loss of grasses. This site is within the Purgatoire River State Wildlife Area and probably had not been grazed in recent years.

Figure 26A.
June 7, 1907, 4.25 miles south of Atchison, Topeka and Santa Fe Railroad tracks, Las Animas, 100 feet east of road, looking east. (Sec. 28, T23S, R52W; Photo No. 1907-11)

Figure 26B.
July 13, 1949, same location as that shown in figure 26A. (Photo Nos. 1949-123, D-8-1949)

Figure 26C.
August 28, 1985, same location as that shown in figure 26A and 26B. (Photo No. 1985-123)

CHANGES IN THE LESS STABLE COLORADO SANDHILLS

General Description

The sandhills-mixed type varies so much that a general description is difficult. The type ranges from a very open *Schizachyrium scoparium* type to an active sand dune type. Usually the larger grasses such as *Calamovilfa longifolia* and *Andropogon hallii* form large clumps or sods, often many feet across, and do not have the *Schizachyrium scoparium* bunching habit. Intermingled with these larger grasses are *Bouteloua hirsuta*, *Bouteloua gracilis*, *Aristida longiseta*, and *Psoralea tenuiflora*. Generally present and sometimes most prominent are plants of *Artemisia filifolia*. Large numbers of associated species of the region are found, but not as dominant species. In general, the color of the sandhills-mixed community varies from light green to silvery.

The soil on which the sandhills-mixed community grows usually contains more sand than that under the bunchgrass type. Plowing sandhills land usually produces blowouts. Nevertheless, by 1985, extensive acreages of almost pure sand had been plowed and were being irrigated by center-pivot irrigation systems. The principal crop being grown was corn. Should the irrigation be discontinued before a permanent vegetational cover can be reestablished, these areas will erode severely.

North of Wray

A sandhills-mixed type on a hill north of Wray in 1914 is shown in figure 27A. Both 1913 and 1914 were hot and dry and growth was not luxuriant. The bunches of *Yucca glauca* stood out most noticeably, and practically all had flower stalks. Many other plants typical of this type were present, such as *Artemisia filifolia*, *Artemisia dracunculus*, *Andropogon hallii*, *Redfieldia flexuosa*, *Mentzelia nuda*, *Liatris punctata*, *Bouteloua hirsuta*, *Aristida longiseta*, *Calamovilfa longifolia*, *Palafoxia sphacelata*, *Ipomoea leptophylla*, *Commelina crispa*, *Tradescantia occidentalis*, *Rumex venosus*, *Argemone polyanthemos*, *Abronia fragrans*, *Penstemon ambiguus*, *Cycloloma atriplicifolium*, *Amaranthus powellii*, *Froelichia gracilis*, *Cryptantha thyrsiflora*, *Muhlenbergia pungens*, *Helianthus petiolaris*, *Psoralea lanceolata*, *Croton texensis*, *Cyperus filiculmis*, *Oryzopsis hymenoides*, and *Petalostemon villosum*.

In 1940, as shown 26 years later in figure 27B, the *Yucca glauca* plants were in the same locations as in 1914. They did not stand out as prominently as in 1914, largely due to the greater prominence of *Artemisia filifolia* and the grasses, which had greatly increased. Annuals had also increased. Although the years 1931 to 1939 were hot and dry, precipitation in early spring of 1940 was above the average, and on June 15, 1940, when the photograph shown in figure 27B was made, the vegetation was actively growing. The principal species were *Yucca glauca*, *Artemisia filifolia*, *Mentzelia nuda*, *Bouteloua gracilis*, *Stipa comata*, and many annuals including *Helianthus petiolaris*, *Chenopodium leptophyllum*, *Lepidium densiflorum*, and *Plantago patagonica*.

Although not obvious in the photographs, plants of *Mentzelia nuda* were in the same locations they had been 26 years before. This was astonishing and may have been happenstance. The age of the old crowns could not be determined but they seemed to be at least several years old and may have been the same plants. This species dies to the ground every few years, which complicates the observation. There was little change in abundance of *Yucca glauca*, but *Artemisia filifolia* and grasses increased greatly. *Andropogon hallii* was not evident.

This area was photographed again in 1949, but the photograph is not suitable for reproduction. Field notes and the photograph both indicate that the vegetation had increased in cover and production from 1940. Plants previously listed were still present, the most prominent being *Yucca glauca*, *Artemisia filifolia*, *Calamovilfa longifolia*, *Bouteloua hirsuta*, *Bouteloua gracilis*, *Mentzelia nuda*, *Helianthus petiolaris*, and *Sporobolus cryptandrus*.

In 1985, the vegetation was much changed from that shown in the 1914 and 1940 photographs (figure 27C). There had been a dramatic reduction in *Yucca glauca* and a corresponding increase in grasses and *Artemisia filifolia*. The dominant species were *Calamovilfa longifolia* and *Artemisia filifolia*, but also present were *Bromus tectorum*, *Mentzelia nuda*, *Yucca glauca*, *Stipa comata*, *Sporobolus cryptandrus*, *Muhlenbergia pungens*, and *Ipomoea leptophylla*. This area did not appear to be grazed much and appeared to be a well-stabilized sandhills-mixed site.

Figure 27A.
June 19, 1914, north of Burlington Railroad tracks at Wray. The vegetation was of the sandhills-mixed type. (NW1/4, Sec. 6, T1N, R43W; Photo No. F-1-1914)

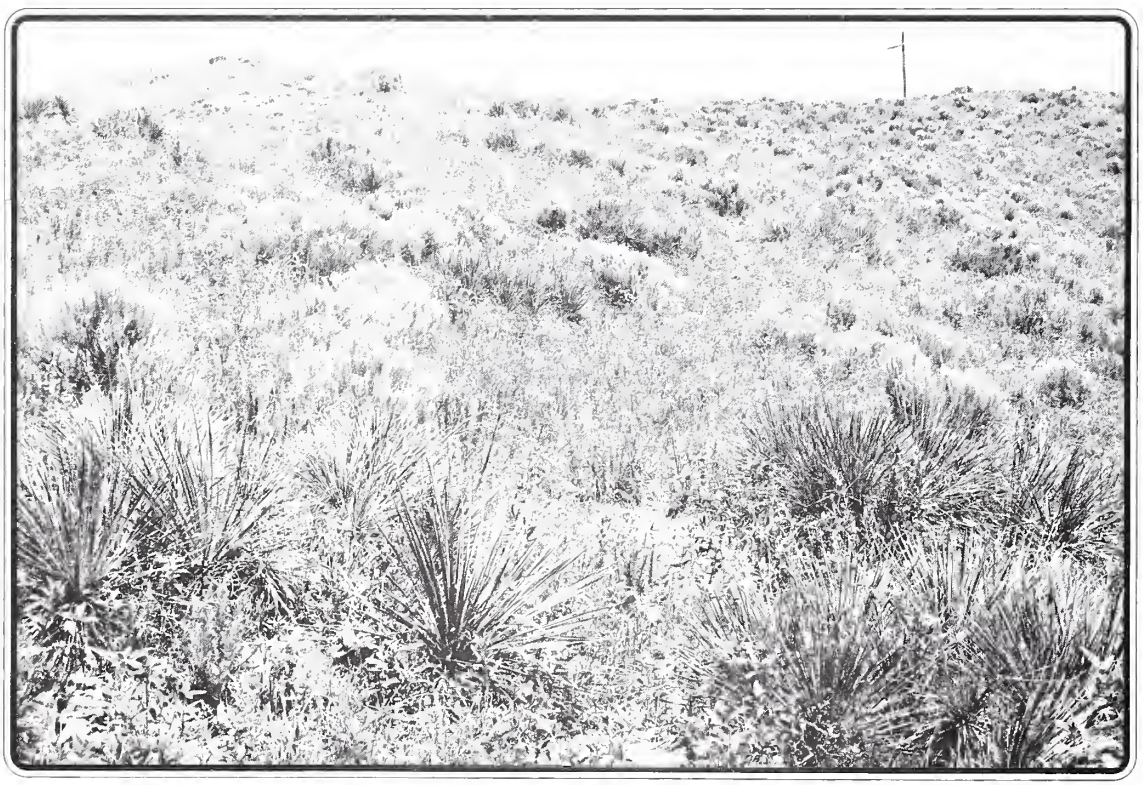


Figure 27B.
June 15, 1940, same location as that shown in figure 27A. (Photo No. C-1-1940)

Figure 27C.
July 31, 1985, same location as that shown in figure 27A and 27B. (Photo No. 1985-274)

—*Yucca glauca* (small soapweed)

CHANGES IN THE SANDHILL BLOWOUTS

General Ecology of Blowouts

On the high plains in eastern Colorado are large areas of blown sand, locally known as the sandhills. In the early part of the 20th century, the more stable sandhills were covered with open to dense stands of *Schizachyrium scoparium*. The less stable sandhills were occupied by a sandhills-mixed type dominated by *Calamovilfa longifolia, Bouteloua gracilis, Aristida longiseta, Oryzopsis hymenoides, Psoralea tenuiflora, Artemisia filifolia, Yucca glauca, Mentzelia nuda,* and a host of other species.

Areas of moving sand, especially where the craters known as blowouts occur, are usually invaded by *Redfieldia flexuosa* (or sometimes *Oryzopsis hymenoides*) and *Psoralea lanceolata*, followed by *Artemisia filifolia* and still later by *Schizachyrium scoparium* and *Calamovilfa longifolia*. During the hot, dry years 1931 to 1940, *Muhlenbergia pungens* became the dominant invader in most of the more open areas.

The changes in vegetation in these blowouts are more rapid than those in any other type of vegetation in the high plains region. More species are involved than in other types, and they collectively show a remarkable range in adjustment to environment. Most of the shortgrass plants, except *Buchloe dactyloides*, are involved, as well as many species more characteristic of the prairie farther east. Many of these changes were documented by photographs and notes and are discussed in the following sections. Dodd's Large Blowout was studied in the most detail because it provides the best record of plant succession.

Dodd's Large Blowout

The area known as Dodd's Large Blowout afforded an opportunity to study changes in sandhill vegetation. This blowout, one of the larger in Yuma County, is located southeast of Yuma and consists of a fairly stable, elongated depression with an active crater on the southeast end. The entire blowout measures over 2000 feet from northwest to southeast; whereas the 60-foot-deep crater within it is about 400 feet east-west and 600 feet north-south. The slope of the crater is steepest on the west side and least steep on the east and south. The photographs to be shown were taken looking southeast from a small hill on the west side of the crater. In 1985, the road that formerly curved around the east end of the blowout had been moved westward following the section line across the east rim of the crater, and a center-pivot irrigation system had been installed east of the blowout.

In 1914 the vegetation in the foreground was of the sandhills-mixed type, consisting primarily of *Yucca glauca, Bouteloua hirsuta, Calamovilfa longifolia, Bouteloua gracilis,* and *Oryzopsis hymenoides* (figure 28A). Lower down at the left, the vegetation was primarily *Schizachyrium scoparium*, with many *Artemisia filifolia*. At the edge of the crater in the background the prominent species were *Yucca glauca, Calamovilfa longifolia, Andropogon hallii,* and often *Prunus besseyi*. *Yucca glauca* and *Prunus besseyi* root deeply, and often 20 feet or more of the root was exposed in the crater.

In 1949 (figure 28B) the vegetation was more luxuriant than in 1914 because of cooler temperatures and higher precipitation from 1941 to 1949. A sandhills-mixed community was in the foreground near the top of the hill. The vegetation on the slope beyond was chiefly *Redfieldia flexuosa, Calamovilfa longifolia, Yucca glauca, Artemisia filifolia, Mentzelia nuda, Palafoxia spinacelata,* and *Oenothera pallida*. Prairie plants such as *Panicum virgatum* and *Schizachyrium scoparium* were also present. On the outside bank of the crater, prominent plants were *Yucca glauca, Psoralea tenuiflora, Mentzelia nuda, Muhlenbergia pungens,* and *Heliantlius petiolaris*.

In 1985, the crater was dominated by *Muhlenbergia pungens, Artemisia filifolia, Yucca glauca,* and *Redfieldia flexuosa* (figure 28C). Thelma Noble, the owner of the land, reported that *Yucca glauca* had increased greatly in recent years. The bottom of the crater was dominated by *Bromus tectorum*; this probably will be replaced by *Bouteloua gracilis* in future years. Other species present on the sidehills included *Gutierrezia sarothrae, Mentzelia nuda, Calamovilfa longifolia, Panicum virgatum, Sporobolus cryptandrus,* and *Aristida longiseta*. Cattle trails were more common than in previous years, and many deer tracks were seen in the area. Except for the trails and a few small disturbed areas, this site seemed to be fairly well stabilized. The vegetation in this crater, which was younger than the remainder of the blowout, generally was in a less advanced stage of succession.

Figure 28A.
July 17, 1914, Dodd's Large Blowout 9.3 miles south and 2.5 miles east of Yuma, looking southeast from a small hill on the west side of the large open crater. (Sec. 7, T1S, R47W; Photo No. K-1-1914)

Figure 28B.
August 16, 1949, same location as that shown in figure 28A. (Photo Nos. 1949-287, FF-12-1949)

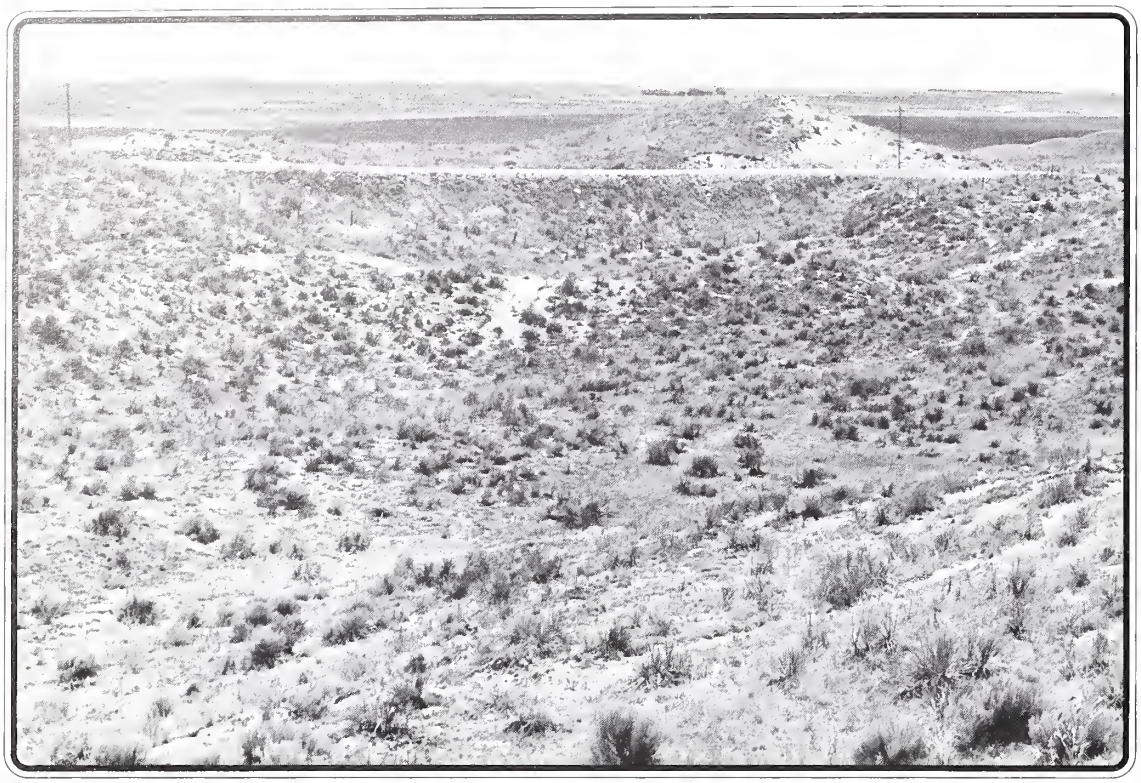


Figure 28C.
July 18, 1985, same location as that shown in figure 28A and 28B. A road had been built along the hill at the east end of the crater, and a center-pivot irrigation system installed beyond the hill. (Photo No. 1985-287)

—*Buchloe dactyloides* (buffalograss)

Stages of Natural Revegetation in Crater of Dodd's Large Blowout

In 1914, Shantz made a detailed photographic study of the different stages of revegetation in the large crater shown in figure 28A. The results are shown in figures 29 through 34 and are summarized in table 1, along with some observations from 1949. Descriptions of the stages follow.

Stage 1

Stage 1 was evident at the very tops on the south and east sides (figure 29). The sand was bare except for an occasional annual such as *Helianthus petiolaris* and *Polanisia trachysperma*.

Stage 2

Stage 2 was evident just below the bare sand area (figure 30). *Redfieldia flexuosa* had pushed into the bare sand by long slender rhizomes from which stems rose to the surface every 3 to 8 inches; these formed a very open stand of long, narrow leaves, with panicles open and relatively inconspicuous. There were also a few *Psoralea lanceolata*, which also pushed under the sand and sent up shoots every few inches from the long, slender underground rhizomes. *Redfieldia flexuosa* produced about 40 to 60 plants per square meter, *Psoralea lanceolata* produced about 5 to 9 plants, and *Oenothera latifolia* sometimes produced 6 to 10 plants per square meter. There were also *Helianthus petiolaris*, their numbers varying from 1 to 25 per square meter, and in places occasional *Gilia longiflora*, *Polanisia trachysperma*, and *Palafoxia sphacelata*.

Stage 3

In stage 3 (figure 31), *Muhlenbergia pungens* was the principal species, *Redfieldia flexuosa* and *Psoralea lanceolata* having declined to secondary importance. Also present were occasional *Comandra pallida*, *Petalostemon villosum*, *Cirsium plattense*, *Gilia longiflora*, and *Hymenopappus filifolius*.

Stage 4

Stage 4, shown in figure 32, had a rather good stand of *Psoralea lanceolata* and a few *Redfieldia flexuosa*. *Yucca glauca*, *Calamovilfa longifolia*, and *Andropogon hallii* were entering, and there were also a few *Petalostemon villosum*, *Cyperus filiculmis*, *Prunus besseyi*, and *Asclepias arenaria*. *Comandra pallida* and *Muhlenbergia pungens* were giving way to other species.

Stage 5

Figure 33 shows the vegetation of stage 5. *Andropogon hallii* was dominant, *Muhlenbergia pungens* was dying out, and *Psoralea lanceolata* and *Comandra pallida* were confined mostly to the open spaces. *Calamovilfa longifolia* and *Schizachyrium scoparium* were entering, and *Yucca glauca* as well as most of the plants mentioned in the previous stages persisted.

Stage 6

Figure 34 shows the vegetation of stage 6. The bunchgrass *Schizachyrium scoparium* was by far the most important plant, a true dominant. There were still many *Psoralea lanceolata* and a very few *Petalostemon villosum* and *Koeleria cristata*. Also present were a very few *Erigeron canadensis* and *Helianthus petiolaris*, the common annual forbs in the area.

All of the stages from open sand to a rather stable *Schizachyrium scoparium* type were found in Dodd's Large Blowout in 1914. There was little soil difference among the stages, although some organic matter was added in each successive stage. On July 17, 1914, when the preceding photographs were taken, the water content 3 inches below the surface was 2.5 percent under the open sand and 2.7 percent under the *Schizachyrium scoparium*. When moistened and examined after 10 minutes, the bare open sand held 13.0 percent water and the soil under the *Schizachyrium scoparium* 16.7 percent water.

Table 1.
Principal species in different successional stages in Dodd's Large Blowout in 1914 and 1949

Stage	1914	1949
1	Large area of open sand	Small area of open sand
2	*Redfieldia flexuosa* *Psoralea lanceolata*	*Muhlenbergia pungens* *Artemisia dracunculus* *Petalostemon villosum* *Oenothera latifolia* *Psoralea lanceolata* *Asclepias arenaria* *Comandra pallida*
3	*Muhlenbergia pungens* *Redfieldia flexuosa* *Psoralea lanceolata* *Andropogon hallii*	*Muhlenbergia pungens* *Psoralea lanceolata* *Andropogon gerardii* *Mentzelia nuda* *Petalostemon villosum*
4	*Andropogon hallii* *Psoralea lanceolata* *Muhlenbergia pungens* *Redfieldia flexuosa*	*Calamovilfa longifolia* *Schizachyrium scoparium* *Erigeron canadensis* *Artemisia ludoviciana*
5	*Andropogon hallii* *Schizachyrium scoparium* *Muhlenbergia pungens*	Not present
6	*Schizachyrium scoparium*	Not present

—*Sporobolus airoides* (alkali sacaton)

Figure 29.
July 17, 1914, stage 1 revegetation in Dodd's Large Blowout. (Sec. 7, T1S, R47W; Photo No. L-5-1914)

Figure 30.
July 17, 1914, closeup of stage 2 revegetation as seen in the foreground shown in figure 29. (Sec. 7, T1S, R47W; Photo No. L-6-1914)

Figure 31.
July 17, 1914, stage 3 revegetation in Dodd's Large Blowout, same location as that shown in figure 28A. (Sec. 7, T1S, R47W; Photo No. L-5-1914)

Figure 32.
July 17, 1914, stage 4 revegetation in Dodd's Large Blowout, same location as shown in figure 28A. (Sec. 7, T1S, R47W; Photo No. L-2-1914)

Figure 33.
July 17, 1914, stage 5 revegetation in Dodd's Large Blowout, same location as that shown in figure 28A. (Sec. 7, T1S, R47W; Photo No. L-1-1914)

Figure 34.
July 17, 1914, stage 6 revegetation in Dodd's Large Blowout, same location as that shown in figure 28A. (Sec. 7, T1S, R47W; Photo No. K-12-1914)

Vegetation on Northeast Rim of Dodd's Large Blowout

Figure 35A shows the vegetation on the crater rim on August 2, 1913. The foreground is just outside and on the left side of the crater shown in figure 28A. The plants were *Andropogon hallii*, *Yucca glauca*, *Calamovilfa longifolia*, *Yucca glauca*, and *Eriogonum annuum*. At the upper right, the vegetation in the crater proper was *Redfieldia flexuosa*, *Psoralea lanceolata*, *Comandra pallida*, *Ambrosia psilostachya*, a few mats of *Muhlenbergia pungens*, and some *Yucca glauca* and *Prunus besseyi*.

Figure 35B shows that on August 2, 1940, 27 years later and at the end of the long, dry, hot period 1931-1940, the edge of the crater had moved back to the left. Only a small area of the vegetation beyond the edge is shown at the left. It consisted chiefly of *Muhlenbergia pungens*, *Yucca glauca*, and *Artemisia filifolia*. No *Andropogon hallii* or *Schizachyrium scoparium* was present. The vegetation in the crater in 1940 was a rather uniform cover of *Muhlenbergia pungens*, with scattered *Asclepias arenaria*, *Petalostemon villosum*, *Psoralea lanceolata*, *Andropogon hallii*, *Penstemon ambiguus*, *Croton texensis*, *Heliantlus petiolaris*, and *Ratibida columnifera*.

In 1949, after the wet years 1941 to 1949, a great change had taken place, as shown in figure 35C. In 9 years the vegetation had changed from a nearly pure stand of *Muhlenbergia pungens* to a mixture of *Calamovilfa longifolia*, *Bouteloua gracilis*, *Thelesperma megapotamicum*, *Artemisia filifolia*, *Yucca glauca*, *Mentzelia nuda*, *Petalostemon villosum*, *Palafoxia sphacelata*, and a few *Muhlenbergia pungens*, most of which were dying.

In 1988, the area shown in figure 35C had been destroyed by the construction of a new road (figure 35D). Old car tires had been placed on the cut slope to help control erosion. The principal species included*Muhlenbergia pungens*, *Redfieldia flexuosa*, *Gutierrezia sarothrae*, *Mentzelia nuda*, *Dalea enneandera*, *Eriogonum annuum*, *Sporobolus cryptandrus*, and *Oryzopsis hymenoides*.

Figure 36A shows the area to the right of that shown in figure 35A. On August 2, 1913, this area on the east side of the large crater showed all the major stages of revegetation described in conjuction with figures 29 through 34. At the very top the vegetation of *Yucca glauca*, *Andropogon hallii*, *Calamovilfa longifolia*, and *Prunus besseyi* was undermined. Below this and going down nearly to the bottom right were:

Stage 1: bare sand.
Stage 2: *Redfieldia flexuosa*, *Psoralea lanceolata*.
Stage 3: stage 2 plants plus *Muhlenbergia pungens*.
Stage 4: stage 3 plants plus *Andropogon hallii*.
Stage 5: largely *Andropogon hallii* with *Schizachyrium scoparium* entering but still containing remnants of *Muhlenbergia pungens*.
Stage 6: mostly *Schizachyrium scoparium*.

Many other plants occurred in stage 5, including *Comandra pallida*, *Ambrosia psilostachya*, *Asclepias arenaria*, *Petalostemon villosum*, *Heliantlus annuus*, *Gilia calcarea*, *Mentzelia nuda*, *Polanisia trachysperma*, *Evolvulus nuttallianus*, *Eriogonum annuum*, *Artemisia dracunculus*, *Koeleria cristata*, *Penstemon ambiguus*, *Lithospermum incisum*, *Opuntia polyacantha*, *Sporobolus cryptandrus*, *Cryptantha jamesii*, *Aristida longiseta*, *Yucca glauca*, and *Erigeron annuus*.

The area shown in figure 36B is the same as that shown in figure 36A, but after 27 years, which included the hot dry years of 1931 to 1940. The dominant plant cover was *Muhlenbergia pungens* and the stages discussed in relation to figure 36A had mostly disappeared. Even the open sand area shown in 1913 had largely been covered with *Muhlenbergia pungens*. The edge of the crater shown in 1913 had eroded and moved back and to the right. About 50 of the *Yucca glauca* plants had persisted in the area shown, but *Andropogon hallii* and *Schizachyrium scoparium* had disappeared. A few *Artemisia filifolia* had invaded.

The photograph, taken 9 years later in 1949 (figure 36C), shows that the ridge in the back at the right had been reduced still further and that the fences had been changed. The vegetation after the wet years of 1941 to 1949 was chiefly *Calamovilfa longifolia*, *Artemisia filifolia*, *Yucca glauca*, *Bouteloua gracilis*, *Thelesperma megapotamicum*, *Mentzelia nuda*, *Petalostemon villosum*, *Palafoxia sphacelata*, *Eriogonum annuum*, and *Heliantlus petiolaris*. Most of the *Muhlenbergia pungens* was gone. The heavy growth of annuals in 1949 and the luxuriant growth of all plants produced a rather complete cover. Apparently, the plants killed out during the hot, dry years 1931 to 1940 had been slowly coming back during the period 1941 to 1949, but *Andropogon hallii* and *Schizachyrium scoparium* were not yet evident.

In 1985, the vegetation had changed considerably (figure 36D). Some of this change probably resulted from the construction of a new road through the area, and some because of the fence built to protect the adjacent center-pivot irrigation system from livestock. The principal species in the area was *Muhlenbergia pungens*, much of which appeared to be dead, particularly on the hillsides. Other species present included *Calamovilfa longifolia*, *Yucca glauca*, *Gutierrezia sarothrae*, *Andropogon hallii*, *Lygodesmia juncea*, *Physalis heterophylla*, *Mentzelia nuda*, and *Artemisia filifolia*. Generally, the site appeared to be producing well and to be quite stable. There was no obvious reason for the dead *Muhlenbergia pungens*, but even when dead, it appeared to be effectively controlling erosion because of its matlike growth form.

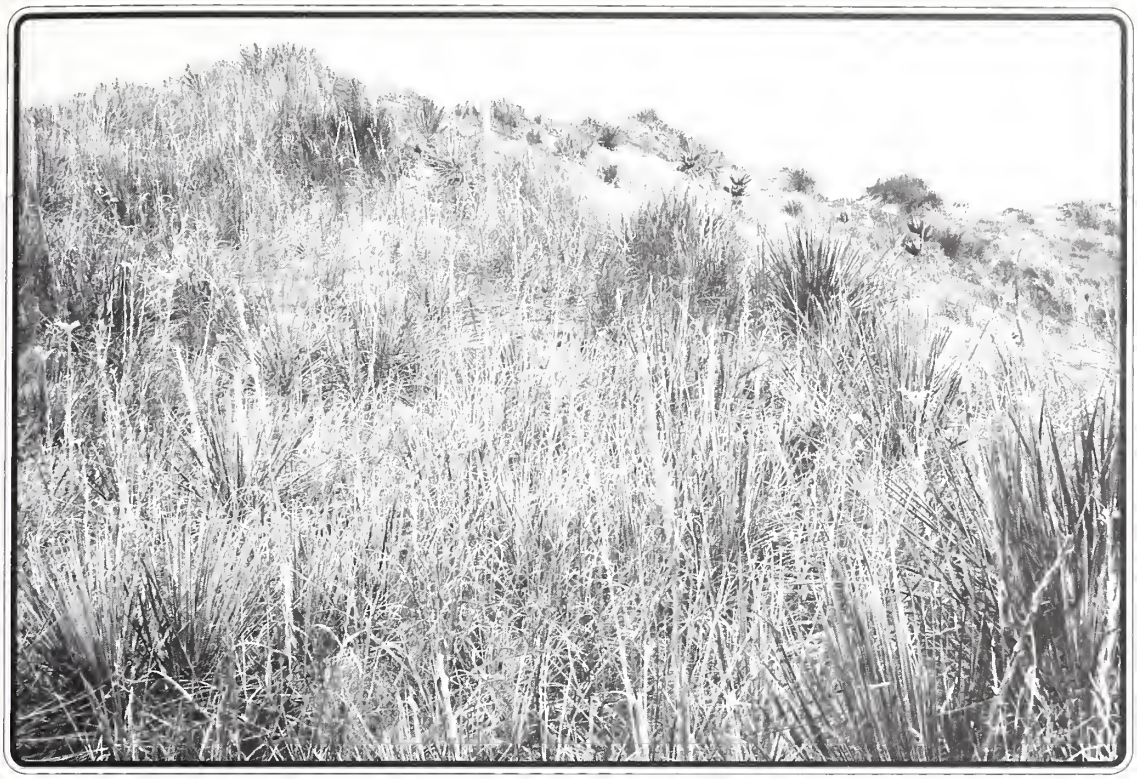


Figure 35A.
August 2, 1913, Dodd's Large Blowout, north edge of large crater, photo looking southeast, just outside of large crater shown in figure 28A. (Sec. 8, T1S, R47W; Photo No. V-11-1913)

Figure 35B.
August 2, 1940, same location as that shown in figure 35A. (Photo No. E-10-1940)

Figure 35C.
August 1, 1949, same location as that shown in figure 35A and 35B.
(Photo Nos. 1949-203, Q-7-1949)

Figure 35D.
August 5, 1988, same location as that shown in figure 35A, 35B, and 35C.
(Photo No. 1988-203)

Figure 36A.
August 2, 1913, Dodd's Large Blowout, east side of the crater at the east end of the blowout. (Sec. 8, T1S, R47W; Photo No. V-10-1913)

Figure 36B.
August 2, 1940, same location as that shown in figure 36A. (Photo No. E-9-1940)

Figure 36C.
August 1, 1949, same location as that shown in figure 36A and 36B.
(Photo Nos. 1949-204, Q-9-1949)

Figure 36D.
July 25, 1985, same location as that shown in figure 36A, 36B, and 36C.
(Photo No. 1985-204)

Small Blowout on Southwest Side of Dodd's Large Blowout

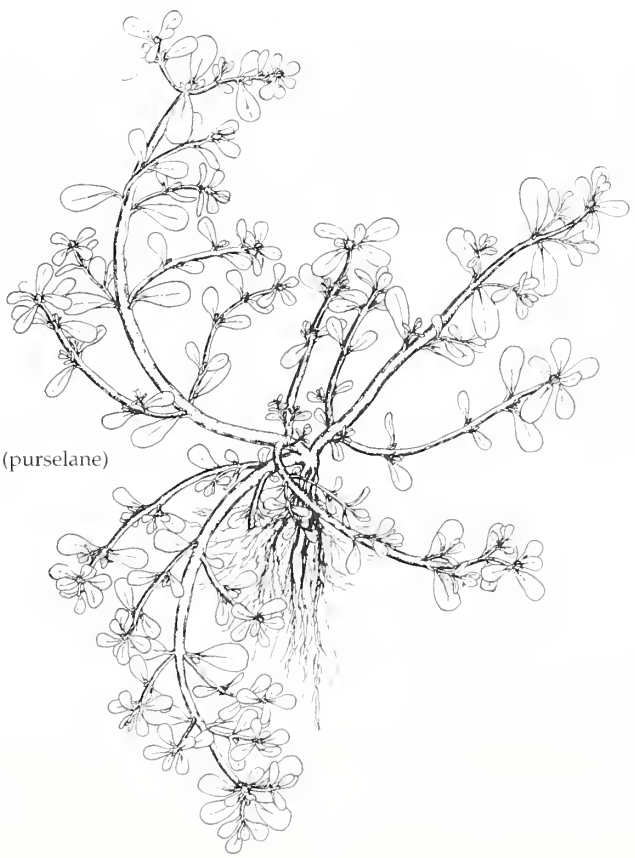
Figure 37A shows a small blowout on the southwest side of Dodd's Large Blowout on August 19, 1909. In the foreground and farther back at the left were a few scattered *Redfieldia flexuosa*, *Petalostemon villosum*, *Oenothera latifolia*, *Andropogon hallii*, and *Muhlenbergia pungens*. At the back and lower right in the bottom of the small blowout, *Schizachyrium scoparium* had established a relatively dense stand.

In figure 37B, on August 16, 1949, or 40 years later, the vegetation in the foreground was *Calamovilfa longifolia*, *Yucca glauca*, *Bouteloua hirsuta*, *Muhlenbergia pungens*, *Mentzelia nuda*, and *Helianthus petiolaris*. A little farther back were *Artemisia filifolia*, and more *Mentzelia nuda* and *Yucca glauca*. Back of this and extending to the first ridges, the sand was almost completely covered with *Muhlenbergia pungens*. The ridge in the back had partially been blown away or dissected; and the vegetation, although not covering the open areas, consisted of about the same species mentioned above. Other plants present were *Palafoxia sphacelata*, *Petalostemon villosum*, *Asclepias arenaria*, and *Comandra pallida*. In the upper right the *Schizachyrium scoparium*, so prominent in 1909, had disappeared.

This area was again visited on June 27, 1953, and is shown in figure 37C. The foreground vegetation was mostly *Muhlenbergia pungens*, but it was partly dead. Other plants were *Calamovilfa longifolia*, many clumps of *Penstemon ambiguus*, *Lithospermum incisum*, *Petalostemon purpureum*, *Mentzelia nuda*, *Tradescantia occidentalis*, *Calamovilfa longifolia*, *Polanisia trachysperma*, and *Yucca glauca* on the ridge. In the mostly open sand area were *Euphorbia serpyllifolia*, *Polanisia trachysperma*, *Muhlenbergia pungens*, *Yucca glauca*, *Penstemon ambiguus*, and *Andropogon hallii*.

Between 1953 and 1985, the greatest changes on this site were the general loss of *Muhlenbergia pungens* and the great increase in both *Yucca glauca* and *Artemisia filifolia* (figure 37D). The dominant species were *Calamovilfa longifolia*, *Stipa comata*, *Bouteloua gracilis*, *Schizachyrium scoparium*, *Andropogon hallii*, *Aristida longiseta*, and *Bouteloua curtipendula*. The area seemed to be quite stable and advancing toward stage 6.

In 1909 this area was sparsely vegetated except in the low part, which had a dense stand of *Schizachyrium scoparium*. After the dry, hot years 1931 to 1940, *Muhlenbergia pungens* formed a nearly pure cover and *Schizachyrium scoparium* disappeared (no photograph available). Nine years later the *Muhlenbergia pungens* was dying but still dominant. After the dry years 1950 to 1953, *Muhlenbergia pungens* was still the ground cover, but many clumps of *Penstemon ambiguus*, one of the most prominent flowering plants, were also present. In 1985, *Muhlenbergia pungens* was again going out of the stand and other species were taking over.



—*Portulaca oleracea* (purselane)

Figure 37A.
August 19, 1909, small blowout within Dodd's Large Blowout, southwest of large crater shown in figure 35A, camera facing southeast. (Sec. 7, T1S, R47W; Photo No. Q-10-1909)

Figure 37B.
August 16, 1949, same location as that shown in figure 37A. (Photo Nos. 1949-286, FF-11-1949)

Figure 37C.
June 27, 1953, same location as that shown in figure 37A and 37B. (Photo No. A-1-1953)

Figure 37D.
July 25, 1985, same location as that shown in figure 37A, 37B, and 37C.
(Photo No. 1985-286)

Lee Side of Dodd's Large Blowout

On September 13, 1911, the vegetation on the lee or back side of the crater rim of Dodd's Large Blowout was a very open but evenly distributed stand of *Redfieldia flexuosa*, with a few *Rumex venosus* (figure 38A). Since sand was constantly being added to this area as it was blown from the crater, the hill was constantly moving. Figure 38B was taken at the same point on the hill on August 2, 1940, but the hill had moved. After the hot, dry years 1931 to 1940, the vegetation was mostly *Muhlenbergia pungens*. There were also *Yucca glauca*, *Mentzelia nuda*, *Asclepias arenaria*, and *Helianthus petiolaris*. *Redfieldia flexuosa* and *Rumex venosus* were absent.

On August 3, 1949, after the wet years 1941 to 1949, the vegetation (figure 38C), was chiefly *Muhlenbergia pungens*, *Yucca glauca*, and *Mentzelia nuda*, the same species prominent in 1940. However, many plants of *Muhlenbergia pungens* were dead or dying. All other plants were larger and more luxuriant. The wet, cool years 1941 to 1949 were unfavorable to *Muhlenbergia pungens* but highly favorable to *Sporobolus cryptandrus*, *Comandra pallida*, *Cycloloma atriplicifolium*, *Psoralea lanceolata*, *Petalostemon villosum*, *Andropogon hallii*, *Palafoxia sphacelata*, *Oryzopsis hymenoides*, and *Opuntia polyacantha*. As in 1940, *Helianthus petiolaris* and *Ascelepias arenaria* were also present.

As shown in figure 38D, rather than becoming more stable, the sand seemed to be loose and moving, as evident from the earlier photographs (figure 38A, 38B, and 38C). Perhaps the new road to the west caused this area to remain unstable. The dominant species was *Muhlenbergia pungens*, but a high percentage of it seemed to be dead. However, even the dead material was helping to hold the soil in place. *Yucca glauca* had increased both in number and size of plants. Other species present included *Gutierrezia sarothrae*, *Calamovilfa longifolia*, *Andropogon hallii*, *Helianthus petiolaris*, *Mentzelia nuda*, *Lygodesmia juncea*, and *Physalis heterophylla*.

Figure 39A shows an area near the crest of the hill and immediately west of the area shown in figure 38A through 38D. The vegetation on September 13, 1911, was an open stand of *Redfieldia flexuosa*, *Andropogon hallii*, *Rumex venosus*, and *Asclepias arenaria* and was almost identical to that shown in figure 38A.

In 1940 no photo was taken, but field notes say the condition was similar to that shown in figure 38B.

On August 3, 1949, after the favorable wet years of 1941 to 1949, there was a rather dense plant cover (figure 39B) of *Muhlenbergia pungens*, *Yucca glauca*, *Mentzelia nuda*, and *Andropogon hallii*. *Redfieldia flexuosa* and *Rumex venosus*, present in 1911, were absent in 1949, and *Andropogon hallii* was much less prominent. Many other species including *Oryzopsis hymenoides*, *Psoralea lanceolata*, *Petalostemon villosum*, *Palafoxia sphacelata*, *Asclepias arenaria*, *Opuntia polyacantha*, *Sporobolus cryptandrus*, *Comandra pallida*, *Helianthus petiolaris*, and *Cycloloma atriplicifolium* were present.

In 1985 (figure 39C), the vegetation was less lush than that shown in figure 39B taken in 1949. The dominant species in 1985 was *Muhlenbergia pungens*, but *Yucca glauca*, *Gutierrezia sarothrae*, *Calamovilfa longifolia*, *Andropogon hallii*, *Helianthus petiolaris*, *Mentzelia nuda*, *Asclepias arenaria*, *Artemisia filifolia*, and *Rumex venosus* were also present. Much of the *Muhlenbergia pungens* appeared to be dead, but because of their matlike nature, the dead plants stabilized the soil surface.

—*Poa pratensis* (Kentucky bluegrass)

Figure 38A.
September 13, 1911, Dodd's Large Blowout, on the southeast or lee side of the rim of the large crater, looking a little west of south. (Sec. 8, T1S, R47W; Photo No. KK-5-1911)

Figure 38B.
August 2, 1940, same location as that shown in figure 38A. (Photo No. F-4-1940)

Figure 38C.
August 3, 1949, same location as that shown in figure 38A and 38B.
(Photo Nos. 1949-229, W-3-1949)

Figure 38D.
July 25, 1985, same location as that shown in figure 38A, 38B, and 38C.
(Photo No. 1985-229)

Figure 39A.
September 13, 1911, Dodd's Large Blowout, same general location as that shown in figure 38A but on the crest of hill, looking northwest. (Sec. 8, T1S, R46W; Photo No. KK-4-1911)

Figure 39B.
August 3, 1949, same location as that shown in figure 39A. (Photo Nos. 1949-230, W-4-1949)

Figure 39C.
July 25, 1985, same location as that shown in figure 39A and 39B. (Photo No. 1985-230)

—*Bouteloua gracilis* (blue grama)

North and South Slopes in Dodd's Large Blowout

The photographs in figure 40A, 40B, and 40C were taken from a point at the extreme northwest end of Dodd's Large Blowout about 2000 feet from the crater located at the southeast end of the blowout. The camera faced east-southeast. The east rim of the crater is the bare-sand area on the horizon near the right-hand side of the photograph. The blowout originated near the camera point and gradually expanded southeast to the present crater. Thus, that part of the blowout closest to the camera point is much older than other parts and had not been actively moving for a considerable period.

In 1908, the open sand was being invaded by *Redfieldia flexuosa*, *Psoralea lanceolata*, *Ambrosia psilostachya*, *Muhlenbergia pungens*, *Cyperus filiculmis*, *Helianthus petiolaris*, *Gilia calcarea*, *Mentzelia nuda*, and *Andropogon hallii* (figure 40A). The foreground and areas between the smaller blowouts were vegetated by the sandhills-mixed type, consisting of *Calamovilfa longifolia*, *Bouteloua hirsuta*, *Artemisia filifolia*, *Yucca glauca*, *Aristida longiseta*, *Muhlenbergia pungens*, and many other plants. At the left in the bottom of the blowout was a small ruderal area with some *Salix* sp. The more level land, the bottoms, and the more favorable locations of the larger blowouts had developed a bunchgrass type that was chiefly *Schizachyrium scoparium*, with *Andropogon hallii*, *Calamovilfa longifolia*, *Bouteloua hirsuta*, and *Bouteloua gracilis* also present. In general, the sandhills-mixed type occurred in the foreground, with *Yucca glauca* and *Artemisia filifolia* abundant.

In 1949, even more of the vegetation was of the sandhills-mixed type than in 1908, with *Calamovilfa longifolia*, *Artemisia filifolia*, and *Yucca glauca* especially abundant on the less stable land in the background (figure 40B). *Bouteloua gracilis* was almost dominant on the more stable bottomland. Over much of the area *Thelesperma megapotamicum*, *Muhlenbergia pungens*, *Eriogonum annuum*, *Mentzelia nuda*, *Petalostemon villosum*, *Palafoxia sphacelata*, and *Lithospermum incisum* were prominent.

In 1985, the vegetation on the rim around the old part of the blowout consisted of *Bouteloua gracilis*, *Stipa comata*, *Yucca glauca*, *Artemisia filifolia*, *Koeleria cristata*, *Carex filifolia*, *Andropogon hallii*, *Calamovilfa longifolia*, *Gutierrezia sarothrae*, and *Muhlenbergia pungens* (figure 40C). Within the old blowout itself, great differences in vegetation resulted from location and exposure. On the southwest-facing slopes, which show up as disturbed areas or bare sand on the left-hand side in the earlier photographs, the vegetation was moderately dense and was dominated by *Redfieldia flexuosa*, *Calamovilfa longifolia*, *Muhlenbergia pungens*, *Artemisia filifolia*, and *Mentzelia nuda*. This vegetation was typical of an earlier successional and more xeric stage. By contrast, the vegetation on the northeast-facing slopes, on the right-hand side of the photograph, was dense and lush, and included *Schizachyrium scoparium*, *Andropogon hallii*, *Bouteloua gracilis*, *Koeleria cristata*, *Sporobolus cryptandrus*, *Aristida longiseta*, *Calamovilfa longifolia*, *Stipa comata*, *Ipomoea leptophylla*, *Panicum virgatum*, *Asclepias arenaria*, *Lygodesmia juncea*, *Artemisia ludoviciana*, *Paspalum stramineum*, *Amaranthus retroflexus*, *Artemisia filifolia*, and *Prunus besseyi*. The soil in the bottom of the blowout is a sandy loam and in a few places showed signs of standing water. The dominant species in the bottom was *Bouteloua gracilis*, and it was mixed with *Calamovilfa longifolia*, *Stipa comata*, and *Artemisia filifolia*. There was very little *Bromus tectorum* in the bottom at the northwest end as contrasted to the abundance of *Bromus tectorum* in the crater at the southeast end of the blowout.

The vegetation in the older part of Dodd's Large Blowout is probably typical of what can be expected in an old and well stabilized blowout following a recent period of average rainfall and an extended period of moderate grazing.

Figure 40A.
September 16, 1908, Dodd's Large Blowout, from the northwest end looking southeast.
(Sec. 7, T1S, R47W; Photo No. Q-1-1908)

Figure 40B.
August 1, 1949, same location as that shown in figure 40A. (Photo Nos. 1949-201, Q-3-1949)

Figure 40C.
July 25, 1985, same location as that shown in figure 40A and 40B. (Photo No. 1985-201)

—*Amaranthus retroflexus* (redroot amaranth)

Lindsey Blowout

Some variation from the changes in Dodd's Large Blowout was shown in the Lindsey blowout (also southeast of Yuma), although the general trend was the same. The Lindsey Blowout is much smaller than Dodd's.

Figure 41A shows the vegetation on the west-facing slope at the east end of the blowout on August 17, 1915. In the foreground was a rather open stand with scattered *Andropogon hallii*, *Calamovilfa longifolia*, *Redfieldia flexuosa*, *Oryzopsis hymenoides*, *Petalostemon villosum*, and *Schizachyrium scoparium* and a few mats of *Muhlenbergia pungens*. In the open sand area in the back there was a mat of *Petalostemon villosum*, and higher up there were *Oenothera latifolia* and scattered *Redfieldia flexuosa*.

Figure 41B shows the vegetation on June 12, 1940. In the foreground there was a nearly closed community of *Muhlenbergia pungens*, which had spread over almost all the unvegetated area in 25 years. In the background the more open cover was *Muhlenbergia pungens*, with scattered *Yucca glauca*.

In 1949 (figure 41C), after the moist period 1941-1949, the vegetation in the foreground was largely *Calamovilfa longifolia*, *Bouteloua gracilis*, *Bouteloua hirsuta*, and *Artemisia dracunculus*. *Bouteloua gracilis* was nearly dominant in the middle background. Vegetation on the slopes in the background was chiefly *Muhlenbergia pungens*, *Calamovilfa longifolia*, *Mentzelia nuda*, and *Yucca glauca*.

The dry, hot years 1931-1940 killed out the taller sandhill grasses and favored *Muhlenbergia pungens*, a xeric grass widely distributed in Arizona and New Mexico on semiarid sandy areas, and resulted in a nearly pure stand of this grass in 1940. During the cool and moist years 1941 to 1949 *Muhlenbergia pungens* began to die out.

In 1985, the vegetation had deteriorated and changed greatly (figure 41D). *Muhlenbergia pungens* was the dominant grass on the hillsides. There had also been a great increase in *Artemisia filifolia*. Other species present included *Redfieldia flexuosa*, *Plantago patagonica*, *Mentzelia nuda*, *Stipa comata*, and *Bouteloua gracilis*. The Lindsey Blowout is located between an old homestead and a watering pond, and had obviously been heavily grazed by livestock over the years. This heavy use by livestock may have been responsible for the changes in vegetation between 1949 and 1985. The local landowner indicated that most of the *Artemisia filifolia* had invaded within the past 20 years. Although this old blowout was in a very depleted range condition, it did appear to be stable except for a few spots along the rim where the cattle trailed to water, particularly along the north side.

Figure 42A shows the vegetation on the south-facing slope at the east end of the blowout on August 17, 1915. The rather open stand consisted of *Andropogon hallii*, *Petalostemon villosum*, *Redfieldia flexuosa*, *Mentzelia nuda*, *Muhlenbergia pungens*, *Artemisia dracunculus*, *Calamovilfa longifolia*, *Oryzopsis hymenoides*, *Schizachyrium scoparium*, and *Andropogon gerardii*.

In figure 42B on June 12, 1940, 25 years later, most of the above plants had disappeared except *Muhlenbergia pungens*, which was then dominant, and a few *Artemisia filifolia*, *Yucca glauca*, and *Mentzelia nuda*.

This blowout was a large, open crater in 1915. A little north of its center *Schizachyrium scoparium* was dominant. To the south of the camera point used for figures 41A and 42A (right in figure 41A) was a larger area of *Andropogon gerardii* and *Andropogon hallii*. The east, south, and west walls were largely bare sand but sustained sparse stands of *Redfieldia flexuosa*, *Petalostemon villosum*, and *Oenothera latifolia*. Below these bare areas the vegetation was chiefly *Andropogon hallii*, *Muhlenbergia pungens*, and *Redfieldia flexuosa*. In 1940, 25 years later and following the hot, dry years 1931 to 1940, *Redfieldia flexuosa* and *Andropogon hallii* had given way to a nearly pure stand of *Muhlenbergia pungens* and infrequent *Artemisia filifolia* and *Yucca glauca* (figure 42B).

Following the favorable years of 1941 through 1949, the vegetation again changed greatly, and *Muhlenbergia pungens* had largely given way to *Bouteloua gracilis*, *Bouteloua hirsuta*, *Calamovilfa longifolia*, *Artemisia filifolia*, *Artemisia dracunculus*, and *Mentzelia nuda* (figure 42C). The *Muhlenbergia pungens* was dying out but was still an important part of the plant community.

By 1985, the vegetation had once more changed drastically, this time because of heavy grazing (figure 42D). In 1985, the area was dominated by a dense stand of *Artemisia filifolia*, with a thick understory of *Muhlenbergia pungens*. Other species present in much lesser amounts included *Redfieldia flexuosa*, *Plantago patagonica*, *Mentzelia nuda*, *Stipa comata*, and *Bouteloua gracilis*. Tops of *Populus sargentii* trees appear above the horizon on the left side of the photograph.

The vegetational changes in this blowout show that species composition is a function of both climate and disturbance. The earliest changes documented were caused by climate. Between 1949 and 1985, when most blowouts in the region showed a general stabilization, this area deteriorated because of abusive grazing pressure. Vegetational improvement in blowouts requires both several years of favorable weather conditions and moderate or conservative grazing.

Figure 41A.
August 17, 1915, east end of Lindsey Blowout, about 5.25 miles south and 7.25 miles east of Yuma, camera facing east. (NE1/4, Sec. 24, T1N, R47W; Photo No. X-9-1915)

Figure 41B.
June 12, 1940, same location as that shown in figure 41A. (Photo No. D-8-1940)

Figure 41C.
July 27, 1949, same location as that shown in figure 41A and 41B. (Photo Nos. 1949-182, N-7-1949)

Figure 41D.
August 7, 1985, same location as that shown in figure 41A, 41B, and 41C. (Photo No. 1985-182)

Figure 42A.
August 17, 1915, south-facing slope at east end of Lindsey blowout, 5.25 miles south and 7.25 miles east of Yuma, camera faces north, same general location as that shown in figure 41A. (NE1/4, Sec. 24, T1N, R47W; Photo No. X-12-1915)

Figure 42B.
June 12, 1940, same location as that shown in figure 42A. (Photo No. D-11-1940)

Figure 42C.
July 27, 1949, same location as that shown in figure 42A and 42B. (Photo Nos. 1949-179, N-1-1949)

Figure 42D.
August 7, 1985, same location as that shown in figure 42A, 42B, and 42C. (Photo No. 1985-179)

Rim of Lindsey Blowout

In 1940, a photo point was established on the east rim of the Lindsey Blowout with the camera facing east, and looking out across typical sandhills country (figure 43A). The edge of the blowout, in the foreground of the photograph, was dominated by *Muhlenbergia pungens*, the midground by *Yucca glauca*, and beyond this by *Artemisia filifolia*. There were also a few *Calamovilfa longifolia*, *Mentzelia nuda*, and *Helianthus petiolaris*. In the background, on the broad expanse of level ground, the vegetation was partly *Artemisia filifolia*, with an understory of grasses consisting mostly of small amounts of *Bouteloua gracilis*, *Bouteloua hirsuta*, and *Calamovilfa longifolia*. Many annuals such as *Lepidium densiflorum*, *Lappula redowskii*, and *Cryptantha minima* and a few small *Salsola iberica* were also present.

In 1949, the vegetation was chiefly *Muhlenbergia pungens*, *Artemisia dracunculus*, *Mentzelia nuda*, *Helianthus petiolaris*, *Petalostemon villosum*, and *Asclepias arenaria* in the foreground and *Cenchrus pauciflorus* and *Cyperus filiculmis* near the blowout (figure 43B). Farther back, *Artemisia filifolia* had increased greatly in number and size. The understory vegetation was mostly *Bouteloua gracilis*, *Bouteloua hirsuta*, *Calamovilfa longifolia*, *Bouteloua curtipendula*, *Stipa comata*, *Artemisia dracunculus*, *Erigeron canadensis*, and *Helianthus petiolaris*.

In 1940, the original bunchgrass cover of *Schizachyrium scoparium* had been largely killed out, and the shortgrasses had formed an open cover in which many weeds were prominent. By 1949, *Calamovilfa longifolia* and *Artemisia filifolia* and other plants had developed. In the foreground, the change was from a blowout cover of *Muhlenbergia pungens* to a sandhills-mixed type.

In 1985, the foreground had reverted to *Muhlenbergia pungens* and*Artemisia filifolia* (figure 43C). The biggest change was in the level expanse in the background. It was now dominated by a mixture of grasses and showed a dramatic increase in both the number and size of *Artemisia filifolia*. A great increase of *Artemisia filifolia* in recent years had been general throughout the sandhills region in Yuma County.

Figure 43A.
June 12, 1940, from the east rim of Lindsey Blowout, looking east across typical sandhills country. (NE1/4, Sec. 24, T1N, R47W; Photo No. E-2-1940)

Figure 43B.
July 27, 1949, same location as that shown in figure 43A. (Photo Nos. 1949-185, O-1-1949)

Figure 43C.
August 7, 1985, same location as that shown in figure 43A and 43B. (Photo No. 1985-185)

Blowout East of Yuma

Figure 44A, taken July 10, 1907, shows the south wall of a small blowout 4.5 miles east and 1 mile south of Yuma. The whole area, which was about 100 yards across, was largely open sand, with a rather even but sparse distribution of *Redfieldia flexuosa*. The patches of vegetation in the open areas, especially in the back at the right, resulted from the invasion of *Calamovilfa longifolia*. Other species included *Cirsium plattense*, *Cryptantha jamesii*, *Eriogonum annuum*, *Cycloloma atriplicifolium*, and *Ambrosia psilostachya*. Although the patches were very open, they were surprisingly evenly distributed over the area. The more open areas were largely in the right background. The bottom was still dune sand and was well drained.

In figure 44B, the vegetation is shown 42 years later, on July 26, 1949. The open areas were very small by comparison with those shown in 1907, and about half of the open sand area had developed a relatively stable plant cover. The open areas were being invaded by *Redfieldia flexuosa*, *Oryzopsis hymenoides*, and *Sporobolus cryptandrus*, with *Calamovilfa longifolia* entering along the edges. On the more stable slopes, *Andropogon gerardii* was present, and a few plants of *Xanthium strumarium* were prominent. A little higher on the slope, *Artemisia filifolia* was established. Most of the perennial cover in the foreground was *Calamovilfa longifolia*, *Bouteloua gracilis*, *Bouteloua curtipendula*, *Andropogon gerardii*, *Aristida longiseta*, *Sporobolus cryptandrus*, and *Artemisia filifolia*, with only isolated plants of *Schizachyrium scoparium*.

Figure 45A shows in greater detail the July 10, 1907, vegetation in the sandy area that appears in the upper right-hand portion of figure 44A. The photograph for figure 45A was taken after the small boy in figure 44A had moved to the right and to the rear. The vegetation was largely a very sparse but evenly distributed stand of *Redfieldia flexuosa*. The matlike patches in this figure and figure 44A were of *Calamovilfa longifolia*. There were occasional *Petalostemon villosum*, *Schizachyrium scoparium*, and *Ambrosia psilostachya* and a single *Cirsium plattense*. At no point was the vegetation dense enough to hold the sand in place. This blowout was still active, and the established plants did not afford much protection to the soil.

Figure 45B shows the same area 42 years later on July 26, 1949. The camera point had been filled in with soil washed down into the crater and was therefore much higher than in 1907. The vegetation was entirely changed and consisted of a base of *Bouteloua gracilis* with many *Calamovilfa longifolia* and an occasional *Artemisia filifolia*. The change in 42 years was from nearly no cover in 1907 to a relatively uniform vegetational cover in 1949.

When visited in 1985, the entire blowout had been completely destroyed by heavy equipment. The floor of the blowout had been leveled and much sand removed. The site was unusable for repeat photography, but the comparisons through 1949 offer a good example of recovery of a small blowout. Note that in no year was there a record of *Muhlenbergia pungens* being present in this blowout.

—*Ambrosia psilostachya* (western ragweed)

Figure 44A.
July 10, 1907, a blowout 4.5 miles east and 1 mile south of Yuma. The photograph shows no well-established grass cover. (Sec. 28, T2N, R47W; Photo No. 1907-45)

Figure 44B.
July 26, 1949, same location as that shown in figure 44A. (Photo Nos. 1949-167, L-1-1949)

Figure 45A.
July 10, 1907, detailed view of sandy area in figure 44A. (Sec. 28, T2N, R47W; Photo No. 1907-47)

Figure 45B.
July 26, 1949, same location as that shown in figure 45A. (Photo Nos. 1949-168, L-3-1949)

LOCAL VEGETATIONAL CHANGES IN EASTERN COLORADO

Succession Following Plowing at Akron

Figure 46A, taken in 1909, shows a plowline contrast located at the Central Great Plains Research Station east of Akron. The native vegetation on the right half of the photograph was dominated by *Bouteloua gracilis* and *Buchloe dactyloides*. The area on the left, which had been plowed in 1908 and abandoned that same year, had a nearly pure stand of *Chenopodium leptophyllum*.

Just four years later in 1913 the vegetation at the left was a nearly pure stand of *Agropyron smithii*, which had grown from rhizomes scattered by plowing (figure 46B).

In 1937 this same area was photographed and is shown in figure 46C. *Agropyron smithii* had entirely disappeared and *Bouteloua gracilis* and *Buchloe dactyloides* had reestablished during the dry years following 1931. There was no great difference between plowed and native vegetation. The area was later plowed, and no record could be obtained in 1949.

General observations in eastern Colorado indicated that if conditions of moisture and temperature were favorable, *Agropyron smithii*, with creeping rhizomes, could establish itself on much of the plowed shortgrass land, at least for a short period. The adaptability of *Agropyron smithii* to cooler and moister conditions is also indicated by the fact that farther north and east, it is a prominent plant, especially on clay soils.

Figure 46A.
June 29, 1909, plowline contrast at the Central Great Plains Research Station east of Akron. (Photo No. D-10-1909)

Figure 46B.
September 15, 1913, same location as that shown in figure 46A. (Photo No. SS-6-1913)

Figure 46C.
May 24, 1937, same location as that shown in figure 46A and 46B. (Photo No. G-1-1937)

Abandoned Roadway West of Yuma

The healing and revegetation of an abandoned roadway are illustrated in figure 47A, 47B and 47C. In 1937, the vegetation on the road abandoned 12 years before was largely *Schedonnardus paniculatus*, with many *Aristida longiseta*. On both sides, but shown most clearly on the right, was a broad band of *Buchloe dactyloides* which had spread from the undisturbed shortgrass. Just outside the band, in the shortgrass and best shown on the right, was a grass stand with nearly equal amounts of *Bouteloua gracilis* and *Buchloe dactyloides*.

In 1949, after another 12 years, or about 24 years since the road had been abandoned, the vegetation on the abandoned roadway could barely be distinguished from the undisturbed shortgrass at the sides. The background had been fenced and plowed (figure 47B). The notebook at the right (cropped out of large photo but shown in small photo inset) marked the edge of the roadway. The vegetation at the right of the notebook was *Bouteloua gracilis* and *Buchloe dactyloides*. At the left, *Buchloe dactyloides* was more important, but *Bouteloua gracilis* was becoming increasingly abundant. *Erigeron canadensis* and *Helianthus annuus* were common. *Schedonnardus paniculatus* and *Aristida longiseta* had given way entirely to the two shortgrasses.

In 1985, this field had been plowed and planted to wheat. But there was an unplowed, abandoned roadway on a railroad right-of-way that bordered the south edge of the field (figure 47C). The right-of-way had been mowed several weeks previously. The vegetation was dominated by *Aristida longiseta* but included considerable *Stipa comata*, *Bouteloua gracilis*, and *Agropyron smithii* and a few *Psoralea tenuiflora*. *Bromus tectorum*, abundant throughout the area, made an excellent growth in 1985. C. H. Wasser, Professor Emeritus of Range Ecology, Colorado State University, Fort Collins, Colorado (personal communication), reported that *Bromus tectorum* became prominent in the plains region following the high rainfall years of the 1940's, which in turn followed the widespread drought of the 1930's.

Figure 47A.
September 12, 1937, roadway north of Burlington Railroad, west of Yuma, camera looking a little north of east. (Sec. 19, T2N, R48W; Photo No. N-2-1937)

Figure 47B.
August 17, 1949, same location as that shown in figure 47A. (Photo Nos. 1949-289, GG-4-1949)

Figure 47C.
July 16, 1985, abandoned roadway west of Yuma on railroad right-of-way several hundred yards south of photo point used for figure 47A and 47B. (Photo No. 1985-289)

Chief Creek West of Wray

In 1907, Chief Creek, the stream flowing east through Wray, was photographed 4.5 miles west of town, as shown in figure 48A. The stream flows toward the left. The photograph shows many old meanders on the right; the one in the foreground was very recently abandoned. The area had been heavily grazed, and there were no willows or trees along the banks of the stream. In the bottom the vegetation was chiefly *Bouteloua gracilis* and in the wetter places *Distichlis stricta*, indicating some salt or alkali. The land was sandy on the left of the stream and a sandy loam on the right toward the hills. In 1907 the vegetation on the sandy loam was largely *Bouteloua gracilis*, with bunches of *Schizachyrium scoparium* increasing toward the tracks (Burlington Railroad) and on to the top of the hills. The vegetation in the foreground and on the left bank of the stream was sandhills-mixed and included *Artemisia filifolia, Bouteloua hirsuta, Calamovilfa longifolia, Ambrosia psilostachya, Heterotheca villosa, Aristida longiseta, Petalostemon purpureum, Evolvulus nuttallianus, Psoralea tenuiflora, Muhlenbergia pungens, Liatris punctata, Croton texensis, Linum lewisii, Calylophus serrulata, Stephanomeria tenuifolia, Sphaeralcea coccinea*, and *Psoralea lanceolata*.

A repeat photograph (figure 48B) taken in 1949 shows that between 1907 and 1949 the creek bottom had entirely changed. Some of the old meander channels had nearly disappeared, although the stream still followed much the same channel, cutting in closer to the camera point and cutting farther into the hill at the left. The channel beyond this point had straightened, cutting off the first peninsula at the left and the second one on the right. It then turned left and cut into the hill at the left farther than shown in 1907. Across the stream at the right, the old meander and bare moist sand shown in 1907 were almost obscured in 1949 by sandhills-mixed vegetation, of which *Artemisia filifolia, Calamovilfa longifolia, Argemone polyanthemos*, and *Bouteloua gracilis* were prominent. *Salix* sp. appeared along the channel in the center of the picture. Also, at the center and to the extreme left were *Populus sargentii* trees.

The vegetation in the foreground (figure 48B) was still sandhills-mixed and consisted of all the plants present in 1907. Most prominent were *Artemisia filifolia, Eriogonum annuum, Muhlenbergia pungens, Sporobolus cryptandrus, Calamovilfa longifolia*, and *Andropogon hallii*. The hills in the back showed little change except for less *Schizachyrium scoparium* and more *Gutierrezia sarothrae* and *Artemisia filifolia*.

In 1985, the foreground vegetation was still a sandhills-mixed type, with essentially the same species as in previous years (figure 48C). The vegetation on the hills in the background was dominated by *Bouteloua gracilis* but also included *Bouteloua curtipendula, Schizachyrium scoparium, Mentzelia nuda, Aristida longiseta, Stipa comata, Andropogon gerardii, Gutierrezia sarothrae, Sporobolus cryptandrus, Yucca glauca, Ribes aureum, Psoralea lanceolata*, and *Artemisia filifolia*. The meadow between the creek and the railroad bed contained *Calamovilfa longifolia, Poa pratensis, Carex* sp., *Agropyron smithii, Juncus* sp., *Schizachyrium scoparium, Andropogon hallii, Bouteloua curtipendula, Sorghastrum nutans*, and *Panicum virgatum*. To the right (west) of the area shown in the photograph was an abandoned railroad bed covered by a thick layer of cinder ballast. This railroad bed was covered by an almost pure stand of *Schizachyrium scoparium* and a few scattered *Andropogon gerardii*. Apparently, the lack of competition from other species allowed these two species to become established on this harsh site.

Figure 48A.
August 13, 1907, Chief Creek, which flows east through Wray, 4.5 miles west of Wray, Burlington Railroad in back. (Sec. 32 or 33, T2N, R44W; Photo No. 1907-92)

Figure 48B.
August 14, 1949, same location as that shown in figure 48A. (Photo Nos. 1949-268, CC-8-1949)

Figure 48C.
July 17, 1985, same location as that shown in figure 48A and 48B. The *Populus sargentii* were gone, replaced by *Salix* sp. (Photo No. 1985-268)

—*Distichlis stricta* (inland saltgrass)

Near Fremont Butte

Figure 49A shows vegetation on a shale outcrop at Fremont Butte in 1913. Soil on the butte is thin and rocky and tends to be low in fertility. In 1913, the plant cover characteristic of such areas in this region consisted of many different species with none strictly dominant. Species observed were *Gutierrezia sarothrae, Artemisia frigida, Hymenoxys acaulis, Eriogonum effusus, Hymenopappus filifolius, Eriogonum alatum, Paronychia jamesii, Calylophus serrulata, Psoralea tenuiflora, Haplopappus spinulosus, Heterotheca villosa, Eriogonum jamesii, Bouteloua curtipendula, Artemisia dracunculus, Koeleria cristata, Lesquerella ludoviciana, Grindelia squarrosa, Cryptantha thyrsiflora, Hymenoxys scaposa, Lithospermum incisum, Schizachyrium scoparium, Artemisia bigelovii, Sphaeralcea coccinea, Plantago patagonica, Opuntia fragilis, Mentzelia nuda, Petalostemon purpureum,* and *Yucca glauca.*

Figure 49B shows the same area in 1949. The plants were still sparse and of the same species. The interridge site, with greater soil depth, contained *Artemisia ludoviciana, Artemisia frigida, Bouteloua gracilis, Agropyron smithii, Astragalus bisulcatus,* and *Erigeron canadensis.*

Between 1913 and 1949, floral composition changed remarkably little but ground cover increased noticeably. Precipitation was under 17 inches in 1913 but over 20 inches in 1949, an increase that would affect the size of many plants. The *Yucca glauca* plants on the left were larger due to greater age, and some new ones had developed.

In 1985, the original camera point was occupied by a fence corner, so a photograph was taken from a point slightly northwest (to the right) of the original camera point (figure 49C). As in the earlier period, there had been little change in the vegetation between 1949 and 1985. The clumps of *Yucca glauca* were still in the same location, although they had expanded and were tending to break up. The most common species was *Bouteloua gracilis,* but other species included *Carex filifolia, Gutierrezia sarothrae, Antennaria* sp., *Aristida longiseta, Bouteloua curtipendula, Stipa comata, Eriogonum annuum, Sporobolus cryptandrus, Cirsium plattense, Buchloe dactyloides, Agropyron smithii, Opuntia fragilis, Lithospermum incisum,* and *Cryptantha crassisepala.*

Figure 49A.
July 6, 1913, at Fremont Butte, northwest of Akron. (Sec. 3, T3N, R53W; Photo No. N-11-1913)

Figure 49B.
August 11, 1949, same location as that shown in figure 49A. (Photo Nos. 1949-260, BB-1-1949)

Figure 49C.
July 30, 1985, same location as that shown in figure 49A and 49B except that camera point was moved slightly to the northwest (to the right). (Photo No. 1985-260)

CHANGES ON TREE CLAIMS IN EASTERN COLORADO

The story of tree claims begins with the Timber Culture Act of 1873. This act encouraged forestation by allowing patent to 160 acres of the public domain to any settler planting and maintaining 40 acres of timber in treeless sections of the West. As a result, a number of tree claims were planted in eastern Colorado between 1873 and 1900. The histories of those claims followed much the same pattern, but with some variations due to soil conditions, planting preparations, and care after planting. Three examples have been documented by a photographic record extending from 1908 to 1949. Unfortunately, little is known about the early history of these tree claims, but the first pictures record them in a healthy condition after 18-25 years of growth. None of the trees remained in 1985, partly because some of the claims had been converted to cropland.

The first tree claim to be considered can be followed from 1908, when it was 18 years old, to 1949, 59 years after it had been planted. In 1908 the claim showed a good stand of *Fraxinus pennsylvanica*, with seedlings growing on the well-shaded floor (figure 50A). The 18-year-old trees were about 15 feet tall, with trunks 2 to 4 inches in diameter. The slight ridge to the left of the tree line marks the edge of the area plowed when the trees were planted. The strip between the plowline and the trees afforded an opportunity to observe successional changes in native vegetation over a period of 18 years. An even stand of *Aristida longiseta* had developed by 1908 on the plowed soil. With normal secondary succession, the *Aristida longiseta* would be replaced by a shortgrass cover, but by 1916 subsequent grazing reduced the vegetation to a weed stage (figure 50B). In 1916 the trees were a little larger, but heavy grazing had destroyed the tree seedlings.

How much heavy grazing affected the survival of the trees cannot be ascertained, as the next photographic record was obtained in 1937, toward the end of the drought of the 1930's (figure 50C). It is known that hogs and cattle were corralled in the tree claim, which afforded the only available shade during the hot, dry years from 1931 to 1937. The combination of drought and grazing is the probable cause of the serious loss of trees shown in the 1937 photograph. In this picture the boy is standing in the same spot occupied by the two boys in the 1908 photograph (figure 50A). The land had not been cultivated in the interim but was subject to grazing. Most of the trees were dead, and the few remaining were severely stressed by drought and almost leafless. Although the land had not been cultivated, blown soil had piled up in front of where the boy was standing and along the north and, to a lesser degree, west sides of the claim.

Twelve years later, following the favorable growing conditions of the 1940's, some of the old trunks that appeared dead in 1937 showed a surprising recovery (figure 50D). The luxuriant weeds, chiefly *Helianthus annuus*, reflected the favorable growing season in 1949.

Tree claims in eastern Colorado tended to die out, starting with the southeast corner. The next set of photographs show the south side of the claim taken from the southwest corner (figure 51A) and the east side from the southeast corner (figure 51B) on June 30, 1916, the same date as in figure 50B. The explanation offered for the observed pattern is that the hot, dry winds of summer are from the southeast. Also, snow tends to accumulate on the north and west sides, providing a windbreak eventually providing the trees with moisture. This accumulation of snow is aided by the tumbleweeds, other plant materials, and silt deposited by the wind on the north and west sides of these tree plantations.

Another tree claim 3 miles east of Yuma was first photographed on August 10, 1915 (figure 52A). The *Fraxinus pennsylvanica* trees planted in 1886 had largely died out in the left foreground, but had survived at the right rear of the photograph. Figure 52B shows this same stand of trees in 1949.

Many of the trees present in this claim in 1915 survived the drought years prior to 1937, as shown by the growth in a photograph taken on May 24, 1937 (figure 53A). The men in the picture were P. V. Woodhead (left) and H. L. Shantz. At that time 63 of the 51-year-old trees along the south boundary of the tree claim were still alive. In 1949 (figure 53B), only five trees of those shown in figure 53A had survived. The prominent tree in the center of the 1937 photograph was dead. The prominent tree on the right in the 1937 photograph had died at the top and in 1949 was sprouting at the base. The man in the picture was N. A. Smith.

Some tree claims were planted on hard land where a carbonate layer at 12 to 15 inches marked the depth to which moisture usually penetrated and the limit of root penetration by most plants. Figure 54 shows one such claim, photographed in 1908, adjacent to land that had a typical *Bouteloua gracilis* and *Buchloe dactyloides* cover. At the southwest corner and along the west side, the *Fraxinus pennsylvanica* trees were dense and thrifty in 1908. They were also in good condition on the north side. However, on the south and east sides, many trees had died and the grass cover was nearly back to shortgrass, with scattered *Aristida longiseta* marking the disturbed area (figure 55).

By August 1914, in the northwest corner of the claim, the trees were about 13 feet tall and the trunks were 3 to 4 inches in diameter (figure 56). The ground cover was mostly annual weeds. Excavating the roots of one of these trees disclosed that the roots diverged sharply from the trunk and did not exceed 21 to 24 inches in

depth (figure 57), probably the depth to which soil moisture usually penetrated. The carbonate layer at this spot was between 18 and 20 inches below the surface.

Conversely, in another claim located on wiregrass type land with a sandy loam soil which water penetrated easily, the roots of a *Fraxinus pennsylvanica* tree 11 feet 8 inches tall were traced to a depth of 5 feet and were noted to be still going down. This tree claim, shown in figure 58A, as photographed September 1, 1908, included trees of *Juglans nigra* and *Ulmus americana* in addition to the more commonly planted *Fraxinus pennsylvanica*. Despite the deeper root penetration than that observed on the hard lands, most of these trees were dead or dying in 1937 (figure 58B).

Water penetration on shortgrass land similar to that on which the tree claim shown in figures 54, 55, 56, and 57 was located was compared to water penetration on the wiregrass type land on which the above claim (figure 58A and 58B) was located. Marked differences, as follows, were recorded:

	Shortgrass land, tree claim shown in figures 54, 55, 56, and 57	Wiregrass land, tree claim shown in figure 58A and 58B
Depth of penetration of 1 inch of water (inches)	8.7	13.7
Time required for 1/2 inch of water to penetrate the soil (seconds)	540	150
Moisture equivalent (percent)	18.1	9.7
Wilting coefficient (percent)	9.6	4.8

Even with favorable soil conditions, trees on the claim shown in figure 58A were unable to survive the hot, dry years between 1931 and 1937. A photograph taken on September 13, 1937 (figure 58B), showed that the large *Ulmus americana* in the center was dying at the top and that many of the *Fraxinus pennsylvanica* trees were leafless or had disappeared. By 1949 this tree claim had given way to winter wheat, a typical fate of most of the tree claims.

The chapter on tree claims in eastern Colorado is closed, as there were no claims planted after 1900. Most tree claims flourished for a while but eventually were destroyed because of grazing, drought, and lack of care, or they gave way to the pressure to plant more land to crops. Their success as young plantations does, however, indicate that with protection from weeds, fire, and grazing, they could be successfully maintained for a period.

When the locations of tree claims were visited in 1985, all were completely gone. For example, the tree claim east of Yuma had been plowed and was in a center-pivot irrigation system. Yuma County is definitely too dry and is visited by too many droughts to allow the development of long-lived tree plantations without weed control, supplemental irrigation, or perhaps some method to accumulate snow in windbreaks.

Figure 50A.
September 12, 1908, *Fraxinus pennsylvanica* on a tree claim 3 miles west of Vernon, showing the west side as viewed from the southwest corner. (Photo No. F-8-1908)

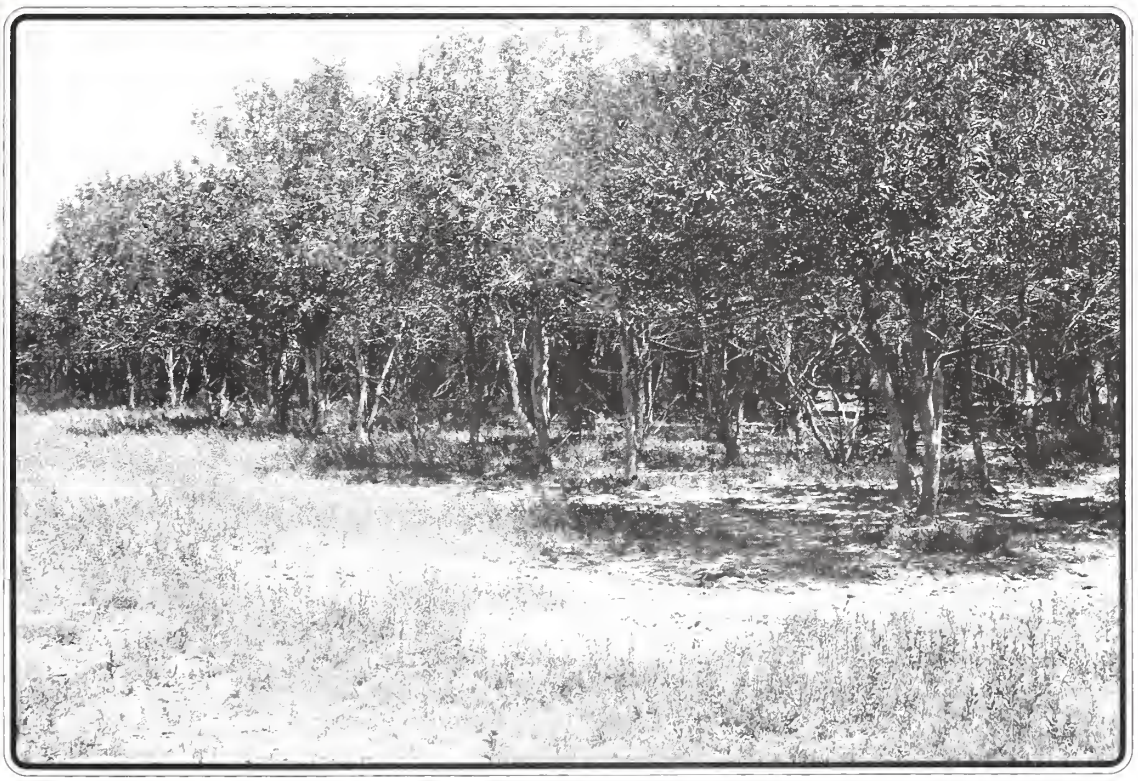


Figure 50B.
June 30, 1916, same location as that shown in figure 50A. (Photo No. F-7-1916)

Figure 50C.
May 23, 1937, same location as that shown in figure 50A and 50B. (Photo No. F-4-1937)

Figure 50D.
August 13, 1949, same location as that shown in figure 50A, 50B, and 50C. (Photo Nos. 1949-267, CC-6-1949)

Figure 51A.
June 30, 1916, tree claim 3 miles west of Vernon, same location as that shown in figure 50B but trees are along the south side, as viewed from the southwest corner. (Photo No. F-8-1916)

Figure 51B.
June 30, 1916, same location as that shown in figure 50B but trees are along the east side, as viewed from the southeast corner. (Photo No. F-10-1916)

Figure 52A.
August 10, 1915, tree claim 3 miles east, 0.2 mile south of Yuma. (Photo No. U-6-1915)

Figure 52B.
July 27, 1949, same location as that shown in figure 52A. (Photo Nos. 1949-171, L-9-1949)

Figure 53A.
May 24, 1937, detail from left background of tree claim shown in figure 52B. (Photo No. F-9-1937)

Figure 53B.
July 27, 1949, same location as that shown in figure 53A. (Photo Nos. 1949-169, L-5-1949)

Figure 54.
September 10, 1908, tree claim 6.5 miles north and a little east of Yuma, southwest corner looking north. (Photo No. 1908-57)

Figure 55.
September 10, 1908, same location as that shown in figure 54, but trees are along the south side, as viewed from the southeast corner. (Photo No. 1908-69)

Figure 56.
August 24, 1914, detail of location shown in figures 54 and 55. Shown is the northwest part of the tree claim, where many *Fraxinus pennsylvanica* trees had survived and made moderately good foliage and height growth. (Photo No. T-7-1914)

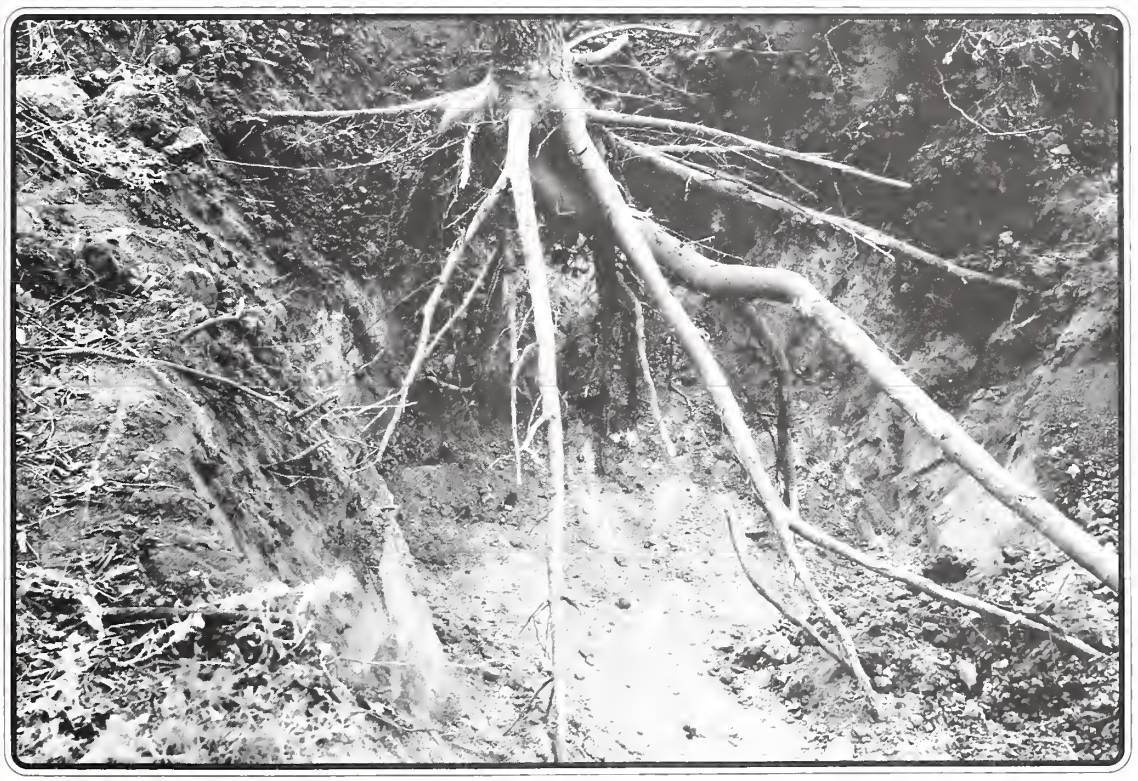


Figure 57.
August 24, 1914, same location as that shown in figures 54, 55, and 56. (Photo No. T-4-1914)

Figure 58A.
September 1, 1908, tree claim 5.25 miles southeast of Yuma. (Photo No. 1908-53)

Figure 58B.
September 13, 1937, same location as that shown in figure 58A. (Photo No. M-5-1937)

CHANGES IN THE VEGETATION ON PLAINS, MESAS, AND FOOTHILLS IN THE MOUNTAIN-PLAINS TRANSITION AREA

General Ecology of Mountain-Plains Transition

The border between the plains and the foothills of the Rocky Mountains has floral elements of both plains and foothills. Some of the prominent plants of eastern Colorado, notably *Buchloe dactyloides*, drop out with increasing elevation, northern exposures, and more pronounced physiographic irregularities. *Yucca glauca* frequently becomes a prominent component of the grassland; and *Cercocarpus montanus*, *Rhus trilobata*, *Quercus gambelii*, *Prunus virginiana*, and *Juniperus monosperma* give the appearance of moving into the grassland. The same is true for *Pinus ponderosa*, especially in the Black Forest area, where *Pinus ponderosa* reaches the lowest elevation and greatest penetration into the plains of Colorado. However, the rate of invasion of these woody plants may be much slower than appears from casual observation. This is brought out by several of the repeat photographs.

Fluctuating weather conditions and the activities of humans have been responsible for many changes in vegetation similar to those noted previously on the plains. Unfortunately, no accurate land use records are available for the areas photographed. In some cases the effects of use are obvious, but in others, it can only be surmised that grazing, burning, and other factors have had an effect on the various components of the vegetation.

Mesa North of Waterworks Northwest of Colorado Springs

In 1904 on The Mesa, northeast of Pike's Peak and northwest of Colorado Springs, a mixed vegetation covered about 60 percent of the soil surface (figure 59A). The vegetation was a mixture of *Bouteloua gracilis* and many other species. Among the most important were *Artemisia frigida*, *Heterotheca villosa*, *Haplopappus spinulosus*, *Aristida longiseta*, *Bouteloua hirsuta*, *Liatris punctata*, *Thelesperma megapotamicum*, *Echinocereus viridiflorus*, *Yucca glauca*, *Eriogonum effusum*, *Senecio mutabilis*, *Petalostemon purpureum*, *Muhlenbergia torreyi*, *Bouteloua curtipendula*, *Cryptantha thyrsiflora*, *Gaura coccinea*, *Euphorbia robusta*, and *Sitanion hystrix*.

In 1949 the same area showed a rather dense stand of young and mature *Yucca glauca* (figure 59B). The grass cover was a nearly pure stand of *Bouteloua gracilis*, but *Artemisia frigida* and *Heterotheca villosa* were also present. The most striking difference was the great increase of mature *Yucca glauca* which, although present in 1904, increased markedly in the 45 years between photographs. There was a similar great increase of *Bouteloua gracilis*, which almost covered the ground in 1949. Other species were by no means as abundant in 1949 as in 1907.

In 1986, the *Yucca glauca* had increased and spread to the northwest (toward the house) (figure 59C). Many of the *Yucca glauca* were young plants. *Bouteloua gracilis* was still the dominant grass but had decreased since 1949. Other plants present included *Sporobolus cryptandrus*, *Aristida longiseta*, *Gutierrezia sarothrae*, *Artemisia frigida*, *Artemisia dracunculus*, *Sitanion hystrix*, *Eriogonum effusum*, *Artemisia ludoviciana*, *Heterotheca villosa*, and *Sphaeralcea coccinea*. Although this area did not seem to be heavily grazed at the time of observation in 1986, it probably had been heavily grazed in the past.

Figure 59A.
August 23, 1904, The Mesa, 0.25 mile north of waterworks northwest of Colorado Springs. (Sec. 35, T13S, R67W; Photo No. 1904-H)

Figure 59B.
August 7, 1949, The Mesa, same location as that shown in figure 59A but viewed from about 150 feet west of Mesa Road. (Photo Nos. 1949-255, AA-5-1949)

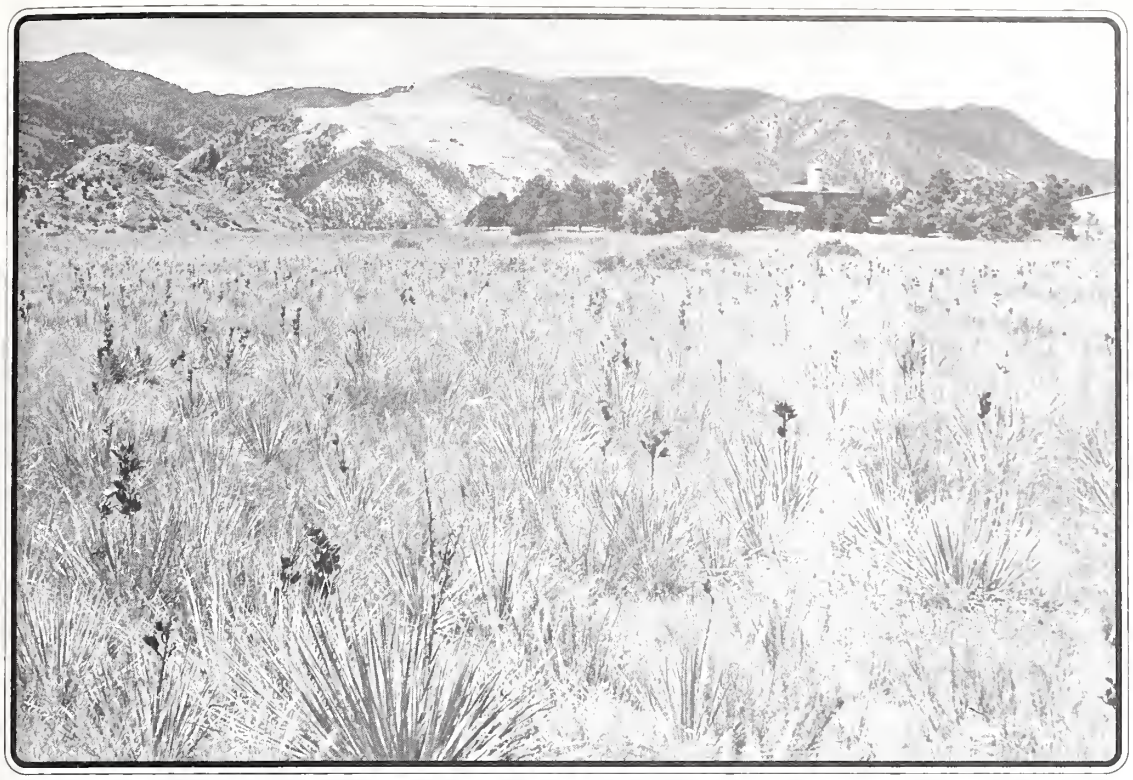


Figure 59C.
July 29, 1986, same location as that shown in figure 59A and 59B. (Photo No. 1986-255)

—*Prunus virginiana* (chokecherry)

Early Successional Stages on Niobrara Ridge

The south end of a limey ridge (Niobrara Ridge) west of Colorado Springs in 1904 had been thought to be an example of an area that was in the early stage of plant succession, which it may truly have been. However, photographs taken in 1949 and 1986 show no significant successional change in 82 years. This lack of change can very well be attributed to poor site conditions wherein geologic erosion on this hot, dry, south-facing slope exceeds the soil-forming processes.

In 1904 the ground cover was very open and consisted of *Lesquerella alpina, Hymenoxys acaulis*, and the annual weed *Salsola iberica* (figure 60A). *Astragalus bisulcatus, Eriogonum jamesii, Gutierrezia sarothrae*, and *Stanleya pinnata* were less abundant. The shrubs were *Rhus trilobata* and *Cercocarpus montanus*, and the three or four trees were *Juniperus monosperma*.

In 1949 (figure 60B) the species were the same as those listed in 1904. The fence post at the left in the 1904 picture had been broken off at the rock surface. The stump is marked by the staff and compass. There were some differences in numbers and distribution of herbaceous plants, but these might have been due to seasonal weather conditions. Two old *Juniperus monosperma* trees, one at the top and one on the left, and an old stump below the tree near the top were evident in 1904 but not in 1949. A small *Juniperus monosperma* had grown near the top and another at the left of the top.

The principal differences between 1904 and 1949 were largely in size of perennial shrubs and a slight increase in the number of *Cercocarpus montanus* and *Yucca glauca* on the face of the hill, and of *Rhus trilobata* and *Juniperus monosperma* on the skyline. There was little or no evidence of invasion here. Although the rock and land had worn away, plants had seeded in about the same number as before. This photographic sequence shows vegetation in a state of dynamic equilibrium with the harsh environment, constantly changing, but with no advance, recession, or apparent succession.

Between 1949 and 1986, the number of understory plants increased substantially, but the species composition remained similar (figure 60C). *Lesquerella alpina* and *Gutierrezia sarothrae* were the dominant species. In addition to species listed in previous years, *Artemisia frigida* and *Oryzopsis hymenoides* were present, but there was no *Salsola iberica* or *Rhus trilobata*. The *Juniperus monosperma* and the *Cercocarpus montanus* had increased in size but not in number of plants. Thus, the principal changes between 1904 and 1986 were the size of the overstory plants and the number of understory plants.

Figure 60A.
October 1, 1904, south end of a limey ridge, an outcrop of Niobrara limestone between Camp Creek and Fountain Creek, above their union in west Colorado Springs. (Sec. 3, T14S, R67W; Photo No. 1904-1)

Figure 60B.
July 5, 1949, same location as that shown in figure 60A. (Photo Nos. 1949-111, B-5-1949)

Figure 60C.
July 29, 1986, same location as that shown in figure 60A and 60B. (Photo No. 1986-111)

On Niobrara Ridge

In 1904 the top of the Niobrara Ridge (the south end of which is shown in figure 60A, 60B, and 60C) in west Colorado Springs had a mixed plant cover, among the most important of which were *Bouteloua gracilis*, *Artemisia frigida*, and *Haplopappus spinulosus* (figure 61A). Grass played a minor role as a soil cover. In contrast, by 1949 grasses dominated the area (figure 61B). *Bouteloua gracilis* was most abundant; but *Muhlenbergia torreyi*, *Sitanion hystrix*, and *Tridens pilosus* were prominent. There were also a few *Artemisia frigida* and *Thelesperma megapotamicum*. In the background in 1904 there had been a few bushes of *Cercocarpus montanus* but no *Yucca glauca*. In 1949 the area contained many plants of *Yucca glauca*. On the hill at the left, the shrubs and *Quercus gambelii* had thinned, but the *Juniperus monosperma* had developed into a prominent tree. In general the foreground had changed from a very mixed open cover, only partly occupied by grasses, to a nearly closed grass cover.

The 1949 photograph does not exactly match the 1904 photograph, but it does match the 1986 photograph (figure 61C). However, the 1904 and 1949 photographs are of the same general location. This area is believed to have been heavily grazed between 1949 and 1986, and 1986 was a dry growing season. Between 1949 and 1986, the *Yucca glauca* increased and the grass, primarily *Bouteloua gracilis*, decreased; but these two species were dominant in both 1949 and 1986. Other species present in 1986 included *Artemisia frigida*, *Cercocarpus montanus*, *Grindelia squarrosa*, *Cirsium plattense*, *Argemone polyanthemos*, and *Muhlenbergia torreyi*. *Pinus edulis* and *Juniperus monosperma* were growing on the east and west slopes of this ridge, but none on top. The vegetation shown in figure 61C is probably typical of what would be expected on heavily grazed rangelands on thin, poorly developed soils along the foothills. These tend to be dry sites. This site and the one at Piñon (shown next) appear to have much in common, although the soil at this site contains much less gravel than the soil at Piñon.

Figure 61A.
June 21, 1904, top of Niobrara Ridge west of Colorado Springs. (Sec. 3, T14S, R67W; Photo No. 1904-2)

Figure 61B.
July 6, 1949, same location as that shown in figure 61A. (Photo Nos. 1949-115, C-4-1949)

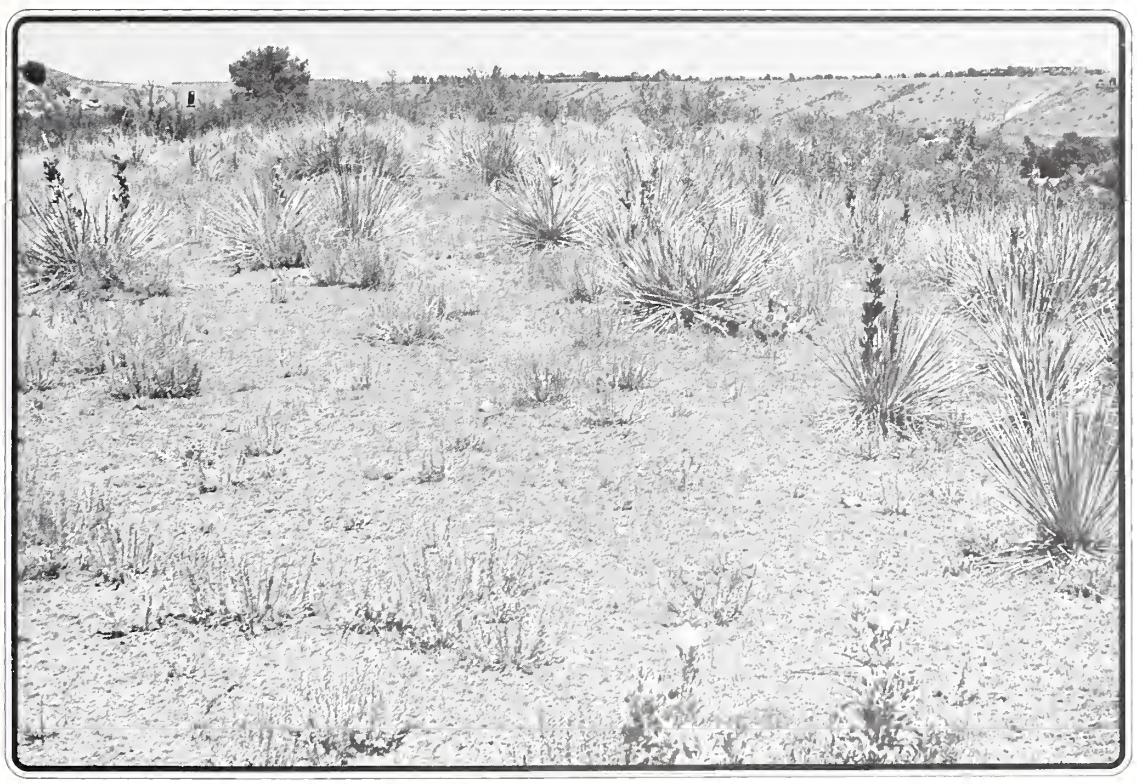


Figure 61C.
July 29, 1986, same location as that shown in figure 61A and 61B. (Photo No. 1986-115)

North of Piñon

The photograph reproduced in figure 62A was taken in 1907 on a ridge top north and a little west of Piñon, between Colorado Springs and Pueblo. The vegetation was a dry foothills type. The ground cover was a very open stand of *Bouteloua gracilis*, *Gutierrezia sarothrae*, and *Eriogonum effusum* interspersed among *Yucca glauca* in the foreground and among *Opuntia imbricata* farther back. Much of the soil surface was bare of vegetation.

Figure 62B shows the same area in 1949. *Artemisia dracunculus*, *Bouteloua gracilis*, and *Opuntia imbricata* were prominent. There were also many *Bouteloua curtipendula*, *Eriogonum effusum*, and *Psoralea tenuiflora*. The chief difference in the 42 years was death of many *Yucca glauca*. *Artemisia dracunculus* was as important in 1949 as *Yucca glauca* was in 1907.

There were small changes in the vegetation between 1949 and 1985 (figure 62C). *Yucca glauca* and *Opuntia imbricata* both increased, along with some increase in the cover of the grasses, mostly *Bouteloua gracilis*. In addition to the species previously reported, *Hilaria jamesii*, *Bouteloua hirsuta*, *Aristida longiseta*, *Oryzopsis hymenoides*, *Stipa robusta*, and *Muhlenbergia torreyi* were present.

The next set of photographs (figure 63A, 63B, and 63C) shows the west slope of the same ridge north of Piñon. The vegetational cover on the slope was much shorter than that on the ridge top shown in figure 62A, 62B, and 62C, but the species were the same. The photo point for the photograph for figure 63A, 63B, and 63C is about 100 feet downhill and to the west of the photo point for figure 62A, 62B, and 62C, and the camera faced south rather than north. This site is an eroded alluvial outwash fan formed from the adjacent mountains. The soils are thin, rocky, and gravely, and the potential for plant growth is generally poor. This is a much more xeric site than the sites described near Colorado Springs; elevation and precipitation are both lower and average temperatures are higher. Note that in figure 63C, the *Populus sargentii* tree is not the same tree shown in figure 63A and 63B. The tree shown in the 1949 photograph (figure 63B) was gone and a new tree had become established slightly downstream from the former tree.

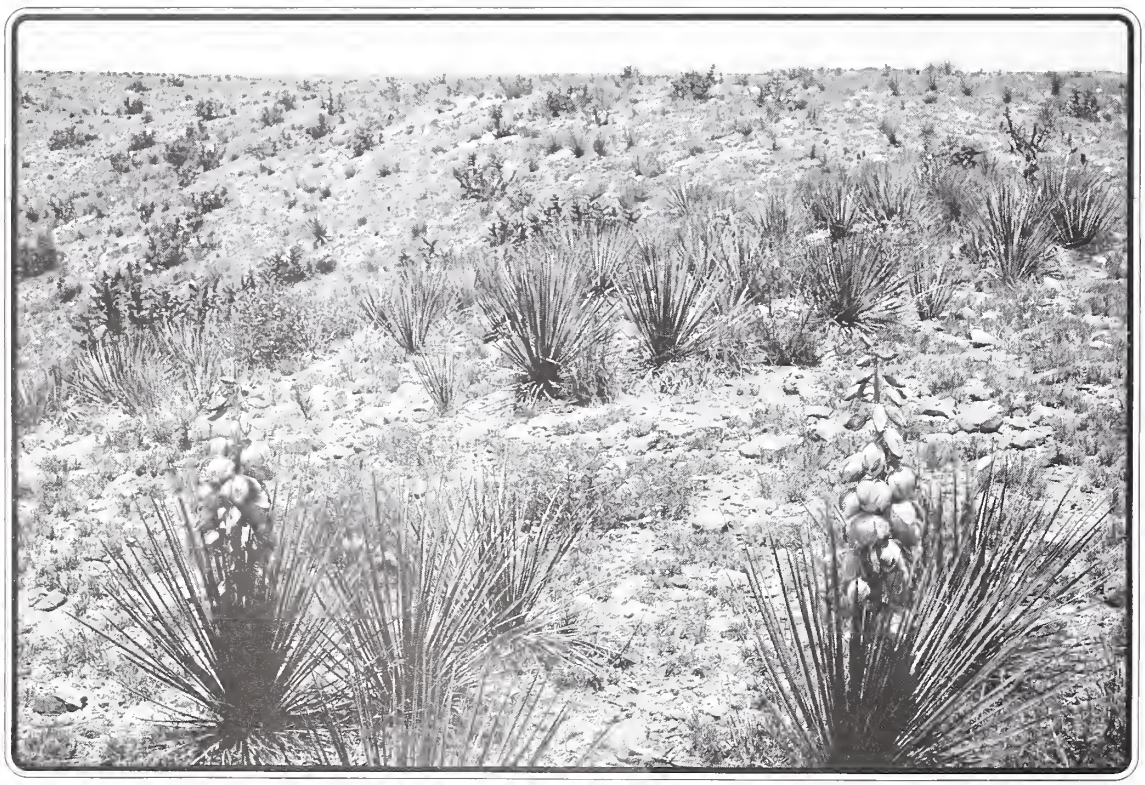


Figure 62A.
June 11, 1907, ridge top north of Piñon, looking north. (Sec. 36, T18S, R65W; Photo No. 1907-28)

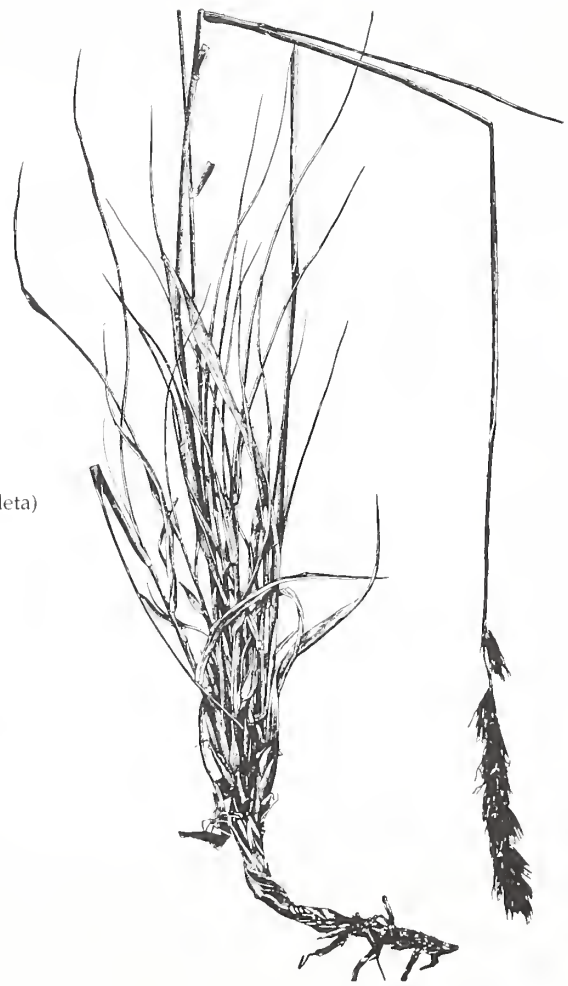
Figure 62B.
July 11, 1949, same location as that shown in figure 62A. (Photo Nos. 1949-119, C-12-1949)

Figure 62C.
August 29, 1985, same location as that shown in figure 62A and 62B. (Photo No. 1985-119)

Figure 63A.
June 11, 1907, looking south from west slope of ridge shown in figure 62A, 62B, and 62C. (Sec. 36, T18S, R65W; Photo No. 1907-29)

Figure 63B.
July 11, 1949, same location as that shown in figure 63A. (Photo Nos. 1949-118, C-10-1949)

Figure 63C.
August 29, 1985, same location as that shown in figure 63A and 63B. (Photo No. 1985-118)



—*Hilaria jamesii* (galleta)

Mesa Slope Near Colorado Springs

A mesa slope with a west exposure near Colorado Springs was photographed in 1904 (figure 64A) and again in 1949 (figure 64B). Because of changes in roads it was not possible to compare vegetational changes on the lower slope of the mesa, but the upper slope remained relatively stable during the 45 years between photographs.

The vegetation on the slope in 1904 (figure 64A) was an open grass cover interspersed with a few bunches of *Schizachyrium scoparium* and a few small shrubs of *Cercocarpus montanus* and *Rhus trilobata*. A zone of *Stipa robusta* grew along the bottom of the mesa. Other important species were *Artemisia frigida, Bouteloua hirsuta, Aristida longiseta, Bouteloua curtipendula, Gutierrezia sarothrae, Chrysothamnus graveolens, Senecio mutabilis, Penstemon angustifolius, Gaura coccinea, Cryptantha thyrsiflora, Schizachyrium scoparium, Yucca glauca*, and *Echinocereus viridiflorus*.

In 1949 (figure 64B) many of the small bushes of *Cercocarpus montanus* and *Rhus trilobata* had grown taller and new ones had become established. The *Stipa robusta* had given way to *Bouteloua gracilis*. Two *Yucca glauca* plants on the right were not present in 1904. *Andropogon gerardii* was found just below the *Rhus trilobata* bushes at the top center. The chief changes were an increase in the size and number of shrubs of *Cercocarpus montanus*, *Rhus trilobata*, and *Yucca glauca*; a great increase of *Andropogon gerardii* below the shrub at the top where *Schizachyrium scoparium* was noted in 1904; and the absence of the zone of *Stipa robusta* at the base of the mesa. There were about five times as many shrubs on the mesa in 1949 as in 1904.

In 1986 this general area had been further disturbed since the 1949 photograph was taken. The mesa to the west of the road had been reshaped and was being developed for housing. Using the 1949 camera point was impossible, so a new camera point was selected north (left) of the 1949 point. However, the area covered by the 1949 and 1986 photographs was approximately the same. Houses had been built on top of the mesa, but did not appear to have had much effect on the vegetation on the slope.

The shrubs appeared to have increased slightly in number between 1949 and 1986, and had grown substantially in size (figure 64C). The greatest change between 1949 and 1986 was the great increase in *Yucca glauca*. The soil on the slope is both rocky and gravely, and *Yucca glauca* is commonly found on similar sites throughout eastern Colorado. Species present on the slope were *Yucca glauca, Cercocarpus montanus, Rhus trilobata, Chrysothamnus graveolens, Heterotheca villosa, Stipa comata, Bouteloua gracilis, Agropyron smithii, Sitanion hystrix, Aristida longiseta, Schizachyrium scoparium, Artemisia frigida, Petalostemon purpureum, Artemisia dracunculus*, and *Andropogon gerardii*.

Figure 64A.
August 4, 1904, mesa slope, Colorado Springs, camera facing east. (Sec. 12, T14S, R67W; Photo No. 1904-R)

Figure 64B.
July 7, 1949, same location as that shown in figure 64A. (Photo Nos. 1949-117, C-9-1949)

Figure 64C.
August 5, 1986, mesa slope, same location as that shown in figure 64A and 64B. The camera point was north (left) of that used in 1949, but the area photographed was approximately the same. (Photo No. 1986-117)

Ten Miles Northeast of Colorado Springs

In 1905 at a point on a ranch about 10 miles northeast of Colorado Springs near the southern fringes of the Black Forest (figure 65A), *Cercocarpus montanus* and *Rhus trilobata* appeared prominently in the foreground. The ground cover was largely *Bouteloua gracilis, Astragalus drummondii, Artemisia ludoviciana*, and, on the lower slopes, *Calamovilfa longifolia*. Other plants were *Bouteloua hirsuta, Aristida longiseta, Andropogon gerardii, Schizachyrium scoparium, Yucca glauca, Thelesperma megapotamicum, Eriogonum effusum, Eriogonum annuum, Liatris punctata*, and *Helianthus petiolaris*. Shrubs were *Cercocarpus montanus* and *Rhus trilobata*. The trees in the back were *Pinus ponderosa*.

In figure 65B the same area is shown as it appeared in 1949. The grasses were more luxuriant but of the same species. *Cercocarpus montanus* was much larger but in exactly the same location it occupied 44 years before. *Populus sargentii* in the back at the left were entirely new in 1949. The *Pinus ponderosa* in the middle right background had increased in size. On the whole, there was almost no change in the 44 years except the increase in size of the shrubs and trees.

Between 1949 and 1986, the *Pinus ponderosa* made little apparent growth (figure 65C). The trees (near the left center of the picture) that had grown noticeably taller were *Populus sargentii*. Note that one small *Pinus ponderosa* tree had become established among the shrubs in the foreground. The shrubs, mostly *Cercocarpus montanus*, were heavily utilized by deer, and deer tracks were common. The greatest change observed in 1986 was the disappearance of the patch of shrubs (possibly *Rhus trilobata*) to the left of the nearest clump of *Pinus ponderosa* trees and the general reduction in size and number of shrubs on the hillside beyond the trees. No obvious reason for the loss of shrubs was apparent, unless it was related to heavy use during winter by cattle or deer. Possibly the area had been plowed. Otherwise, vegetation remained essentially the same as reported in 1905 and 1949.

Figure 65A.
August 5, 1905, ranch about 10 miles northeast of Colorado Springs. (Sec. 3, T14S, R65W; Photo No. 1905-111)

Figure 65B.
July 18, 1949, same location as that shown in figure 65A. (Photo Nos. 1949-134, F-7-1949)

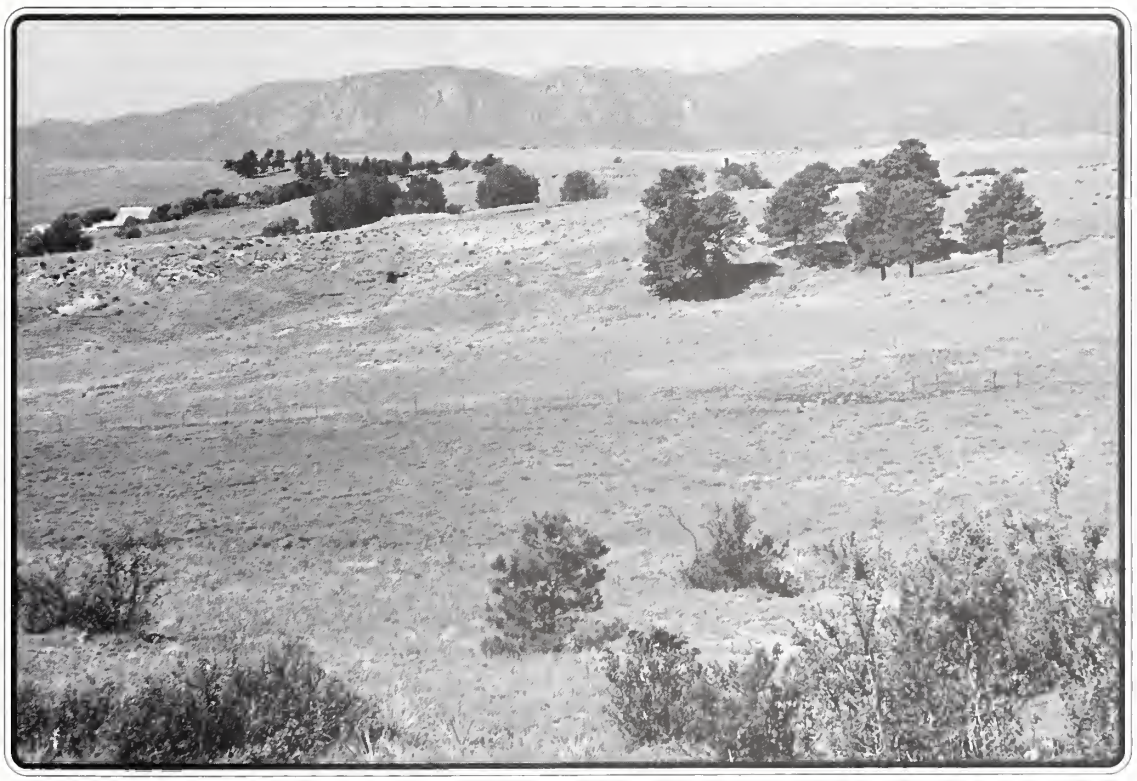


Figure 65C.
August 6, 1986, same location as that shown in figure 65A and 65B. (Photo No. 1986-134)

Near Eastonville

An area on the southern edge of the Black Forest was photographed in 1905 and again in 1949 and 1986. In 1905 (figure 66A) the immediate foreground was sparsely occupied by *Potentilla hippiana, Thermopsis rhombifolia, Eriogonum glandulosum, Paronychia jamesii,* and *Arenaria fendleri.* Just beyond were *Muhlenbergia torreyi, Bouteloua gracilis, Gutierrezia sarothrae,* and *Artemisia dracunculus;* and still farther back, *Carex stenophylla, Hymenopappus filifolius, Heterotheca villosa, Sedum stenopetalum, Artemisia dracunculus, Geranium caespitosum, Cryptantha virgata, Gilia calcarea, Rosa arkansana, Euphorbia robusta, Astragalus gracilis,* and many other species from the foothills.

By 1949 (figure 66B) *Pinus ponderosa* in the background had increased in height in the ratio of 1.3:1 and in some cases 2:1. The bare soil under the trees on the right in 1905 was still bare in 1949, but several of the slopes on the right, bare in 1905, were covered with vegetation in 1949. Otherwise, the 44-year period resulted in surprisingly little vegetational change. Species found in the foreground were *Geranium caespitosum, Hymenoxys acaulis, Paronychia jamesii, Petalostemon oligophyllus, Calamovilfa longifolia, Thermopsis rhombifolia, Campanula rotundifolia, Salix* sp., and *Arctostaphylos uva-ursi.* On the level land beyond were found chiefly *Petalostemon oligophyllus, Salix* sp., *Bouteloua gracilis, Arenaria fendleri, Arctostaphylos uva-ursi, Heterotheca villosa, Castilleja integra, Apocynum androsaemifolium, Aster ericoides, Agropyron smithii, Frasera speciosa, Artemisia dracunculus, Artemisia frigida,* and *Rosa arkansana.*

In 1986 (figure 66C), the area was being developed as a residential area. There was no evidence of recent grazing. The *Pinus ponderosa* trees in the background had grown. A few small *Pinus ponderosa* trees had become established in the open area between the camera point and the older trees in the background, possibly because of the reduced grazing pressure following previous heavy grazing. The bare foreground differed little from that in the previous photographs. The vegetation in the remainder of the area appeared to represent a transition between the shortgrass type and typical mountain grassland commonly found in openings in the *Pinus ponderosa* forest. Some of the more common species were *Bouteloua gracilis, Koeleria cristata, Stipa comata, Sporobolus cryptandrus, Agropyron smithii, Aristida longiseta, Gutierrezia sarothrae, Grindelia squarrosa, Castilleja integra, Artemisia frigida, Heterotheca villosa, Muhlenbergia montana, Antennaria rosea,* and *Schizachyrium scoparium.*

Figure 66A.
August 25, 1905, 0.5 mile west of Eastonville looking over the Black Forest. The camera faced a little south of Pike's Peak. (Sec. 29, T11S, R64W; Photo No. 1905-120)

Figure 66B.
July 19, 1949, same location as that shown in figure 66A. (Photo Nos. 1949-135, F-9-1949)

Figure 66C.
July 31, 1986, same location as that shown in figure 66A and 66B. (Photo No. 1986-135)

CHANGES IN FOOTHILLS THICKET VEGETATION

Greenland Ranch

The foothills thicket vegetation extends along the eastern base of the Rocky Mountains. It often follows ridges and gullies far onto the plains. The most prominent shrubs are *Quercus gambelii*, *Cercocarpus montanus*, and *Rhus trilobata*. Scattered *Juniperus monosperma* and *Prunus virginiana* are sometimes present on the ridges and these species may follow drainages into lower areas.

The intermixture of shrubs and herbaceous vegetation often gives the impression of invasion and instability. However, the following four sets of photographs show rather surprising stability. In protected areas, the shrubs have developed more than they have in the open areas, but there is no indication of a shrub invasion resulting from grazing or other disturbance. These photographs also give some indication of the longevity of the shrubs; by 1986, many of these shrubs would have been 75 years old or more.

A brush-covered butte at Greenland Ranch between Monument and Castle Rock was photographed in 1911 and again in 1949 (figure 67A and 67B). The principal shrubs shown were *Quercus gambelii*, *Cercocarpus montanus*, and *Rhus trilobata*. The shrub line in both photographs was practically the same, and close inspection shows an identical distribution of shrubs. There was also no visible evidence of shrub invasion into the grass or a shrinkage of the shrub area.

No change in this shrub-shortgrass ecotone could be found in 1988 (figure 67C). The shrubs may have been slightly taller, but the areas they occupied remained identical to the areas shown in the previous photographs.

Figure 67A.
June 10, 1911, butte at Greenland Ranch between Monument and Castle Rock, photographed from the Santa Fe Railroad track opposite the loading pen, looking a little north of east. (Sec. 14, T10S, R67W; Photo No. D-7-1911)

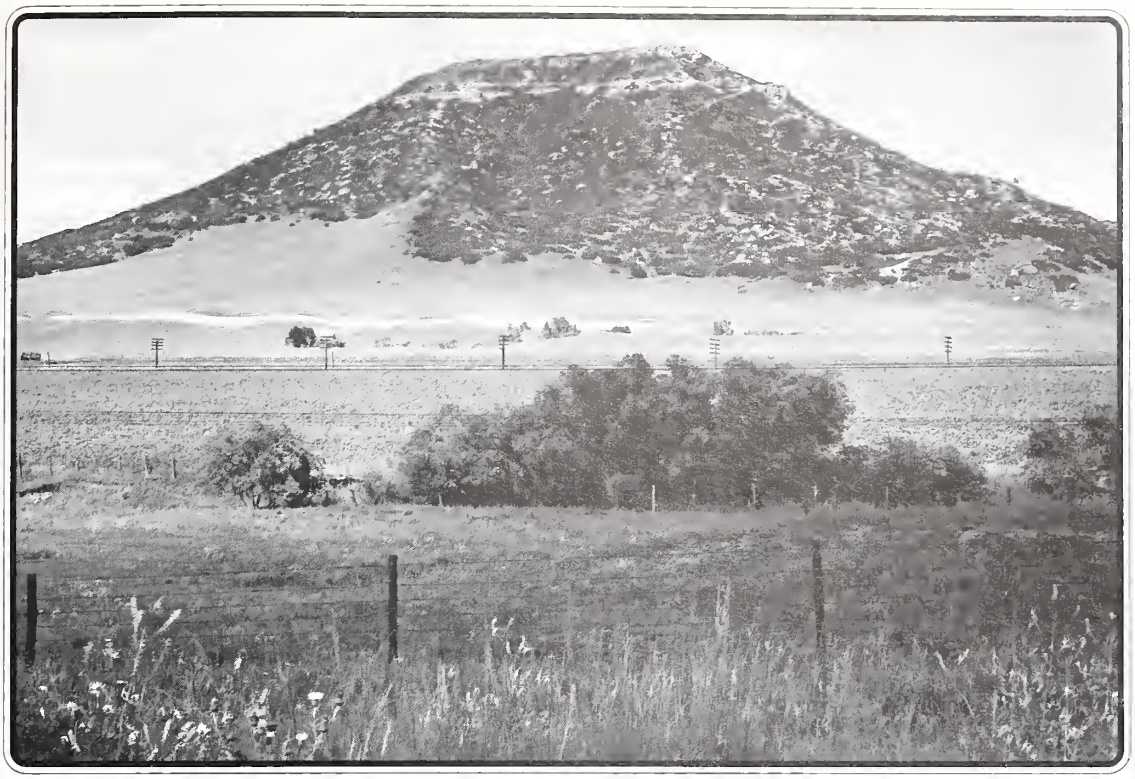


Figure 67B.
July 20, 1949, same location as that shown in figure 67A. (Photo Nos. 1949-140, G-7-1949)

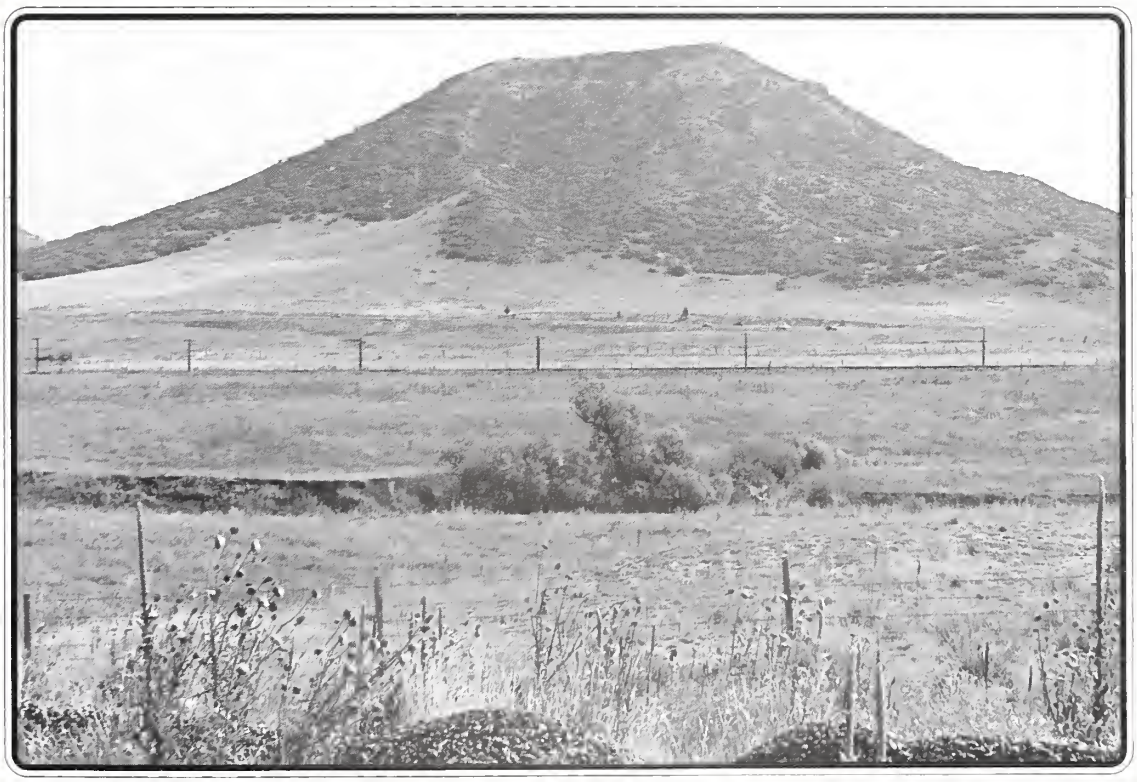


Figure 67C.
September 2, 1988, same location as that shown in figure 67A and 67B. (Photo No. 1986-140)

Base of Cheyenne Mountain

The site shown in figure 68A and 68B is located east of Cheyenne Mountain near the Star Ranch road and near the lower edge of the mountain brush zone. The site was photographed with the camera faced southeast toward Fort Carson. The 1905 photograph (figure 68A) shows *Quercus gambelli* and other brush extending down from the base of Cheyenne Mountain over the grassland, giving the appearance of an invasion.

The photograph taken in 1949 (figure 68B) shows several *Pinus ponderosa* in the central background that were not apparent in 1905. The mass of the dark vegetation, composed almost entirely of *Quercus gambelii*, was exactly where it was 44 years before. There was no advance or recession, but the plants seemed to be a little larger. These two pictures provide impressive evidence of the stability of the *Quercus gambelii* clumps.

In 1986, this entire area had been converted to a housing development, and none of the original native vegetation remained.

—*Quercus gambelii* (gambel oak)

Figure 68A.
August 22, 1905, *Quercus gambelii* brushland east of Cheyenne Mountain. (Sec. 6, T15S, R66W; Photo No. 1905-1)

Figure 68B.
July 6, 1949, same location as that shown in figure 68A. (Photo Nos. 1949-116, C-6-1949)

Cheyenne Mountain

Figure 69A shows Cheyenne Mountain as it appeared in 1905 from west of Broadmoor. The foreground was an open mixed grassland of mainly *Muhlenbergia torreyi* and *Bouteloua gracilis*, with *Koeleria cristata*, *Aristida longiseta*, and *Sporobolus cryptandrus*. The shrubs were *Quercus gambelii*, *Cercocarpus montanus*, and *Rhus trilobata*, and the trees were *Pinus ponderosa* and *Pseudotsuga menziesii*. Other plants were *Heterotheca villosa*, *Anemone patens*, *Thelesperma megapotamicum*, *Artemisia frigida*, and *Artemisia ludoviciana*.

In 1949 (figure 69B), progressive successional changes had occurred in the foreground, and *Bouteloua gracilis*, *Andropogon gerardii*, *Festuca arizonica*, *Trisetum montanum*, *Bouteloua curtipendula*, and *Schizachyrium scoparium* had become dominant. The cover was more luxuriant and more grassy than in 1905. The *Quercus gambelii* had been partly cut out since 1905 by powerline workmen. Behind this zone of *Quercus gambelii*, *Pinus ponderosa* had greatly increased in number and size.

In 1949 on the mountain front at the left, the scattered *Pinus ponderosa* had increased in number to establish a forest. In the center and a little to the left, the conifers were less numerous in 1949 than in 1905. On the right and nearer the top of the mountain, conifers had thickened to form a nearly continuous forest. Many of the trees had been planted in 1918. An estimate of the conifers at the base of the mountain and on the mountain at the left showed an increase in height in the 44 years by a ratio of 2.8:1. Both on the left face of the mountain and at the top of the mountain, the change was from an open or very open stand to a dense stand. In general the vegetation below the mountain had changed from a very mixed cover in 1905 to a dominantly grass cover in 1949, but few if any of the species had been eliminated by the increase of grasses. The *Pinus ponderosa* had probably more than doubled in number during the 44 years. The scar on the mountain was caused by road construction. Other plants not as abundant as they had been in 1905 but still present were *Thelesperma megapotamicum*, *Calyloplus serrulata*, *Petalostemon oligophyllus*, *Liatris punctata*, *Heterotheca villosa*, *Artemisia ludoviciana*, *Artemisia dracunculus*, *Oxytropis lambertii*, *Arenaria fendleri*, *Anemone patens*, *Lupinus plattensis*, *Opuntia fragilis*, and *Yucca glauca*.

In 1986, the original photo point had been destroyed. This area had been subdivided for estate homes. The 1986 photo point (figure 69C) was across the street from No. 13 Upland, west of the Broadmoor Golf Course, and was southwest of the original point. The conifers in the foreground had been planted. The *Quercus gambelii* appeared to be about twice the height it was in 1949. Understory vegetation was a lawn. Trees on the lower slopes of Cheyenne Mountain had increased in number and appeared to have increased in height by at least 50 percent. Trees appeared to be invading the shrub areas on the mountainside. Trees near the top of the mountain had grown to the point where they almost entirely obscured the bare areas.

—*Koeleria cristata* (prairie junegrass)

Figure 69A.
August 22, 1905, Cheyenne Mountain, south of Colorado Springs. (Sec. 35, T14S, R67W; Photo No. 1905-124)

Figure 69B.
July 20, 1949, same location as that shown in figure 69A. (Photo Nos. 1949-139, G-5-1949)

Figure 69C.
August 5, 1986, same general location as that shown in figure 69A and 69B.
(Photo No. 1986-139)

—*Bromus inermis* (smooth bromegrass)

Northeast of the Garden of the Gods

Another example of the slowness of change in a mixed shrub-grass transition zone along the Rocky Mountain foothills west of Colorado Springs is shown in figure 70A, 70B, and 70C. The foreground in the photograph taken in 1904 (figure 70A) was dominated by *Bouteloua gracilis*, which had been overgrazed, and included considerable *Artemisia frigida*. The vegetation in the background was largely the shrubs *Rhus trilobata*, *Cercocarpus montanus*, *Quercus gambelii*, and *Prunus virginiana*, and the trees *Juniperus monosperma* and *Pinus edulis*. *Populus sargentii* grew along Camp Creek. Niobrara ridge is seen at left above the ditch.

In 1949 (figure 70B) the foreground had been plowed and was a weedy field of *Chenopodium leptophyllum*, *Iva xanthiifolia*, *Ambrosia trifida*, *Grindelia squarrosa*, and many other species. The stream-bottom bushes were mostly *Rhus trilobata*, which were larger than they had been in 1904 but still in the same places. The *Populus sargentii* trees along the stream were all gone due largely to the diversion of water to the irrigation ditch on the east (near) side of Niobrara Ridge. The brush below the ditch on the left had thickened and increased in size, probably influenced by seepage from the ditch. This brush was largely *Quercus gambelii*, *Rhus trilobata*, and *Prunus virginiana*. The greatest increase was shown on the right where areas of grassland had been occupied by *Quercus gambelii* and *Rhus trilobata*. These plants had also increased on the lower part of the face of the Niobrara Ridge. Above the ditch and in the center there had also been an increase and extension of *Cercocarpus montanus*, *Rhus trilobata*, and *Juniperus monosperma*, but the larger plants were in the same position in each photograph. On the Dakota Sandstone and the talus below, the shrubs and trees were about the same in the two photographs except that there were fewer shrubs on the cliffs in 1949 than in 1904. However, a remarkable similarity in the photographs above the irrigation ditch indicated the stability of the *Quercus gambelii*, *Rhus trilobata*, *Cercocarpus montanus*, and *Juniperus monosperma* stands.

In 1986 (figure 70C) the foreground was dominated by *Yucca glauca*, *Bouteloua gracilis*, *Stipa robusta*, *Artemisia frigida*, *Bromus inermis*, *Salsola iberica*, and numerous species of annual weeds. The *Quercus gambelii* plants along Camp Creek appeared to be identical to those in 1949, except that they were larger. *Juniperus monosperma* was invading the *Quercus gambelii* at the toe of the slope and along the creek. Trees on the hillside had increased in both size and number since 1949, and shrubs (mostly *Cercocarpus montanus*) appeared to be increasing on some of the grassy slopes. *Quercus gambelii* did not appear to be invading any areas

Figure 70A.
August 20, 1904, Camp Creek, east and north of the entrance to the Garden of the Gods, in west Colorado Springs, photographed from the highway. (Sec. 34, T13S, R67W; Photo No. 1904-12)

Figure 70B.
July 6, 1949, same location as that shown in figure 70A. A, irrigation ditch (not visible) on other side of dense vegetation; and B, stream bed. (Photo Nos. 1949-112, B-10-1949)

Figure 70C.
July 29, 1986, same location as that shown in figure 70A and 70B. (Photo No. 1986-112)

CHANGES IN THE VEGETATION AT THE EDGE OF THE BLACK FOREST

North of Colorado Springs the *Pinus ponderosa* forest, locally known as the Black Forest, extends into the shortgrass plains and typically consists of a patchwork of forest and open grassy parks. The relative stability of the forest-grassland transition is shown in figures 71A through 72C. The first photographs (figures 71A and 72A) were taken in 1913 and repeated in 1949 (figures 71B and 72B) and again in 1986 (figures 71C and 72C).

The man standing under the tree in the center of figure 71B was 5 feet, 11 inches tall. Using this scale, the tree had grown from 21 feet in 1913 (figure 71A) to 44 feet in 1949, or nearly 8 inches a year. The tree at the right showed an even greater growth. Farther back, the trees that were in competition with other trees as well as grass grew at a much slower rate. A few trees on the right had been cut down. There was no evidence of an advance of the trees into the grassland in 36 years.

The photograph shown in figure 72A was taken in 1913 from the same point as 71A but with the camera turned to show the grassland. A replicate taken in 1949 is shown in figure 72B. Of the trees appearing in 1913, one had died and the others increased in height from about 14 feet to nearly 30 feet. The grass cover had thickened and no *Pinus ponderosa* had extended into the grassland.

In 1986, the original photo point was occupied by a shed, so photographs at this location (figures 71C and 72C) were taken from a point somewhat to the east of the original point. This location was described as "east of the residence No. 2050 Highway 105, The Millers." In figure 71C, the camera pointed slightly south (left) of the camera direction in the earlier photographs. There were no obvious changes in the trees except that they had grown taller. A few trees appeared to have become established within the forested area, but no new trees had become established in the grassland. The trees that were about 30 feet tall in 1949 (figure 72B) were over 40 feet tall in 1986 (figure 72C). Two new trees had become established to the left of the older trees, and these were about 30 feet tall. The tree in figure 72B with the man standing beside it was estimated to have grown about 16 feet since 1949, or about 5 inches per year. Other than the growth of the trees, there were no other obvious changes in the forest-grassland border. The grassland shown in figures 71C and 72C was a seeded pasture dominated by *Poa pratensis* and *Bromus inermis* in 1986.

Figure 73A and 73B shows a pair of photographs from the same point, but looking north. Because the trees were much taller than they had been in 1913, the foreground had to be cut in the 1949 photograph. In both photographs, the trees were the same distance from the camera. The trees in the foreground at the left had grown from about 18 feet in 1913 to 30 feet in 1949. Two trees on the right had grown from 13 feet to 30 feet, and a new tree had grown at the side of each of these. There was no evidence of an advance of the *Pinus ponderosa* into the shortgrass.

In 1986, the photograph could not be repeated because a shed had been constructed on the original camera point. The trees had grown taller, but not as rapidly as those near the edge of the forest in figure 71A, 71B, and 71C.

—*Pinus ponderosa* (ponderosa pine)

Figure 71A.
August 12, 1913, 4 miles east of Monument, edge of Black Forest. (Sec. 9, T11S, R66W; Photo No. R-8-1913)

Figure 71B.
July 21, 1949, same location as that shown in figure 71A. The trees had increased in size, but no new trees had developed. (Photo Nos. 1949-145, H-5-1949)

Figure 71C.
July 29, 1986, same location as that shown in figure 71A and 71B. The original camera point was occupied by a shed, so a new point, slightly east of the original was used. The view shown here is slightly south (left) of that shown in figure 71B. (Photo No. 1986-145)

Figure 72A.
August 12, 1913, 4 miles east of Monument, edge of Black Forest. (Sec. 9, T11S, R66W; Photo No. X-2-1913)

Figure 72B.
July 21, 1949, same location as that shown in figure 72A. (Photo Nos. 1949-151, I-5-1949)

Figure 72C.
July 29, 1986, same location as that shown in figure 72A and 72B, but the camera point was moved because a shed had been constructed on the old camera point. (Photo No. 1986-151)

Figure 73A.
August 12, 1913, 4 miles east of Monument, edge of Black Forest, same location as that shown in figures 71A through 72C. (Sec. 9, T11S, R66W; Photo No. W-10-1913)

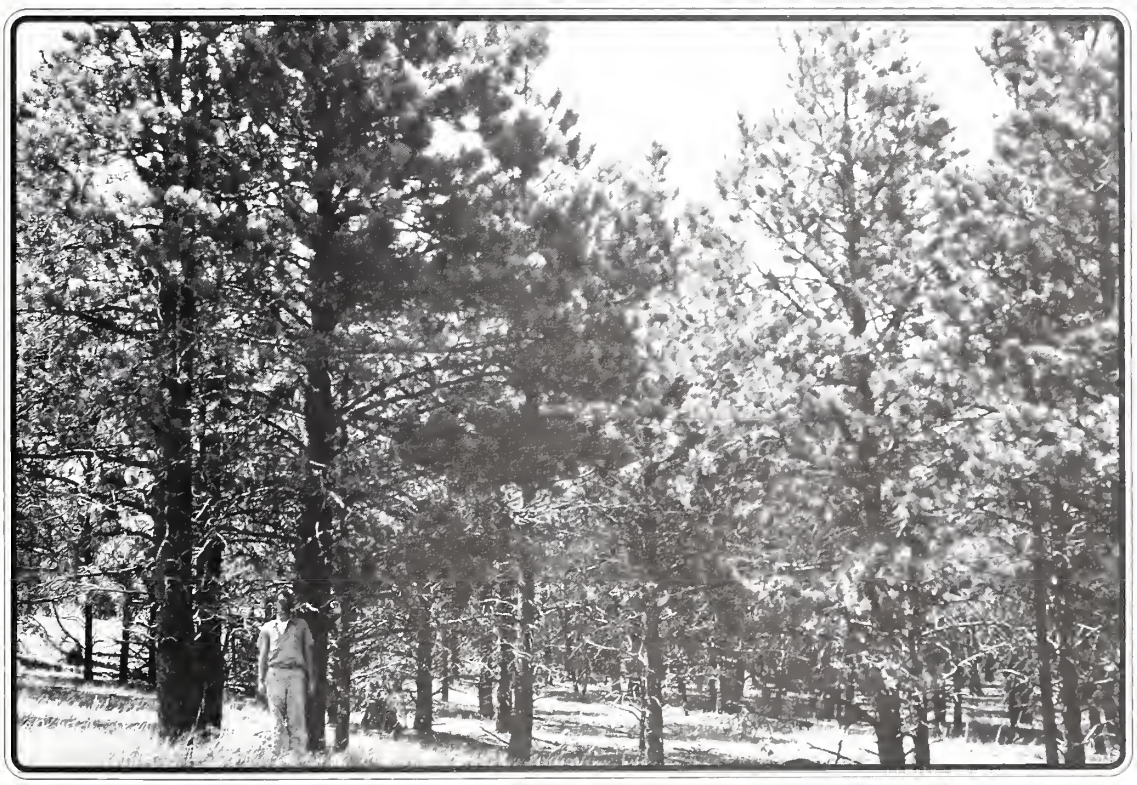


Figure 73B.
July 21, 1949, same location as that shown in figure 73A. (Photo Nos. 1949-147, H-9-1949)

CHANGES IN DRAINAGES

Gully in The Mesa Northwest of Colorado Springs

A large gully in The Mesa northwest of Colorado Springs was photographed in 1905 (figure 74A), 1949 (figure 74B), and 1986 (figure 74C). In 1905 the thicket in the gully was composed largely of *Cercocarpus montanus, Rhus trilobata, Quercus gambelii, Ribes cereum,* and other shrubs (figure 74A). The grasses were *Bouteloua gracilis, Bouteloua curtipendula, Schizachyrium scoparium,* and *Stipa robusta.*

In 1949 (figure 74B) the species were the same, but many differences in distribution could be detected. The shrubs on the hill from which the photograph was taken in 1905 had grown much taller and blocked out some of the foreground. On the hill on the right, the disturbed areas shown in 1905 were largely healed in 1949 by the establishment of a *Bouteloua gracilis* cover. The ditches traversing the hill on the right had all but disappeared. On the right, 9 or 10 shrubs had developed where there had been none 44 years before. The small gully which had cut in from the left had not cut back any further, and the shrubs at its head occupied the same position. On the right slope above the wash, *Populus sargentii* had developed in the foreground and *Quercus gambelii* in the middle of the photograph. On the slope on the right, higher above the gully, shrubs had increased in size and number, and the ground cover changed from ruderals to perennial grasses. Farther up the gully that starts at the top of the hill to the right and in several channels leading to the large gully, much of the surface that had been bare in 1905 was healed by shortgrass vegetation, and shrubs were more numerous. These shrubs were largely *Rhus trilobata* and *Cercocarpus montanus.* Near the top on the right, the shrubs of *Rhus trilobata* were in the same position.

In the main gully in 1905 there was no *Populus sargentii,* while in 1949 two rather large trees appeared in the foreground. The right bank was raw in 1905, but was largely covered with vegetation in 1949, and the trees were much larger. The upper part of the gully was almost identical in the two photographs. The hill at the lower end of the ridge separating the two large gullies at the left, covered with shrubs in 1905, had been cut back in 1949 and was a clean-cut bank almost twice as high as in 1905. The land below this bank was raw in 1905 and fairly well covered with vegetation in 1949. The *Quercus gambelii* just above this cut had nearly doubled in height, but the bank had been cut back several feet nearly to the base of the oak clump. The trees and shrubs in the gully at the left had increased in size and number. Above this cut in the left center, in the second gully, there was a great increase in shrubs, and one rather large tree had been added. At the head of this gully a great increase in shrubs was noted. Similarly, in the center at the top, shrubs, mostly *Cercocarpus montanus* and *Rhus trilobata,* had increased along the upper ridge and the lower slopes. The brush at the left obstructed the view of much of the left foreground and its shrub distribution.

Between 1949 and 1986, a new road and pipeline were constructed from the waterworks (left background) to the city of Colorado Springs (figure 74C). There had been some additional disturbance from motorcycles and four-wheel-drive vehicles using this area. Shrubs (particularly *Cercocarpus montanus*) decreased slightly over the entire area but without any apparent loss of *Quercus gambelii.* The disturbed areas shown in the 1949 photograph were healing over, and shortgrass, rather than shrubs, dominated the vegetation. There appeared to have been little or no grazing on this area in recent years. *Populus sargentii* trees in the drainage had multiplied and were growing vigorously. Species composition of the grasses growing on the hillsides differed little from that described in 1905.

The next series of photographs, taken facing north across the large gully on The Mesa from a point east of where the photographs for figure 74A, 74B, and 74C had been taken shows some distinct changes since 1905. In 1905 (figure 75A) the shrubs in the foreground, chiefly *Cercocarpus montanus,* did not obstruct the view of the bottom of the big gully, but in 1949 and 1986 they did. The vegetation in 1905 on the un-eroded benches and slopes was largely *Bouteloua gracilis, Bouteloua curtipendula, Bouteloua hirsuta,* and *Muhlenbergia torreyi.* The shrubs were largely *Cercocarpus montanus* and *Rhus trilobata,* with a few *Ribes cereum.* The broken areas had been invaded not only by these three shrubs but also by *Chrysothamnus graveolens, Agropyron smithii, Mentzelia nuda, Atriplex canescens, Artemisia frigida, Stipa robusta, Gutierrezia sarothrae,* and many other species.

The changes in vegetation in 1949 (figure 75B) were not so much in species composition but, rather, in the distribution of the shrubs. The small gully on the right had widened by a ratio of about 1.8:1 and had cut back, especially on the left side. The number of shrubs in 1949 was about the same as in 1905. Above the gully on the right, the shrubs present in 1905 were still there but were somewhat larger. Farther back in the photograph, not much difference could be detected. Shrubs had developed on the open cut (ditch-bank) on the face of the hill just left of this small gully. The large clumps below were still present after 44 years. The larger gully was wider at the top in 1949 by a ratio of 1.5:1 and at the mouth of the gully by a ratio of 2.5:1. In this gully a new gully had developed (a second cycle of erosion) in 1949. A grass cover had developed on the sides of this new gully in the bottom of the old gully. On the hillsides just above the head of the main gully, shrubs had increased slightly

in number. In the center of the background, a small patch of *Populus sargentii* had become established. In general, the shrubs seemed to be more than holding their own in competition with the grasses. Although the shrubs were larger and slightly more numerous, almost every plant shown in 1905 was still present in 1949. It is astonishing to see how nearly identical these photographs appear as regards the more stable part of the landscape.

Between 1949 and 1986, a pipeline and road had been constructed in the foreground (figure 75C). This construction may have helped to stabilize the gullies by stopping further downward cutting. Many trails caused by four-wheel-drive vehicles and motorcycles were present. The area to the east (right) of this photograph was being developed as a subdivision, with development gradually moving toward the west. The large gully in the left foreground had cut back (head-cut) a few feet since 1949 but appeared to be stabilizing. There was no additional cutting in the bottom of the gully. The small gully in the right foreground in the 1949 photograph appeared to be largely healed over and was covered with grass, mostly *Bouteloua gracilis*. There had been no change in the number or location of the shrubs, most of which were *Cercocarpus montanus*. Shrub-for-shrub matches could be made between the 1949 and 1986 photographs, although the shrubs were somewhat larger in 1986. Grass vegetation in 1986 on the hillsides was essentially the same as in previous years.

Figure 74A.
August 20, 1905, gully on The Mesa, northeast of Mesa Road, northwest of Colorado Springs, camera facing northwest up the gully. A, large (main) gully; B, lower ditch on the right; C, upper ditch on the right; D, small gully on the left; E, gully on top of hill on the right; and F, two large gullies on the left. (Sec. 1, T14S, R67W; Photo No. 1905-117)

Figure 74B.
July 22, 1949, same location as that shown in figure 74A. A, large (main) gully; B, small gully on left; C, gully on top of hill at right; and D, hill separating the two large gullies (E) on the left. (Photo Nos. 1949-152, I-7-1949)

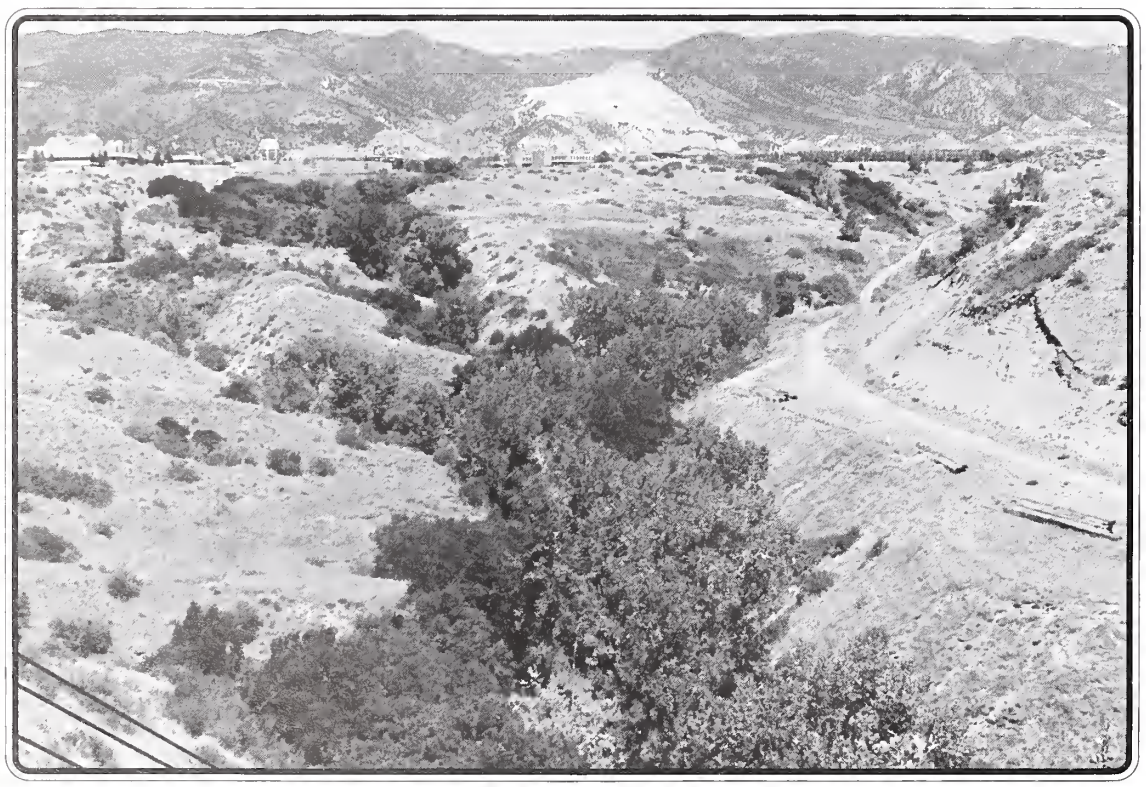


Figure 74C.
July 30, 1986, same location as that shown in figure 74A and 74B. (Photo No. 1986-152)

Figure 75A.
August 20, 1905, gully on The Mesa, northeast of Mesa Road, in northwest of Colorado Springs. The camera faced north across the gully, and the photograph was taken from a knoll to the east of the camera point used for figure 74A, 74B, and 74C. (Sec. 1, T14S, R67W; Photo No. 1905-126)

Figure 75B.
July 22, 1949, same location as that shown in figure 75A. (Photo Nos. 1949-154, I-11-1949)

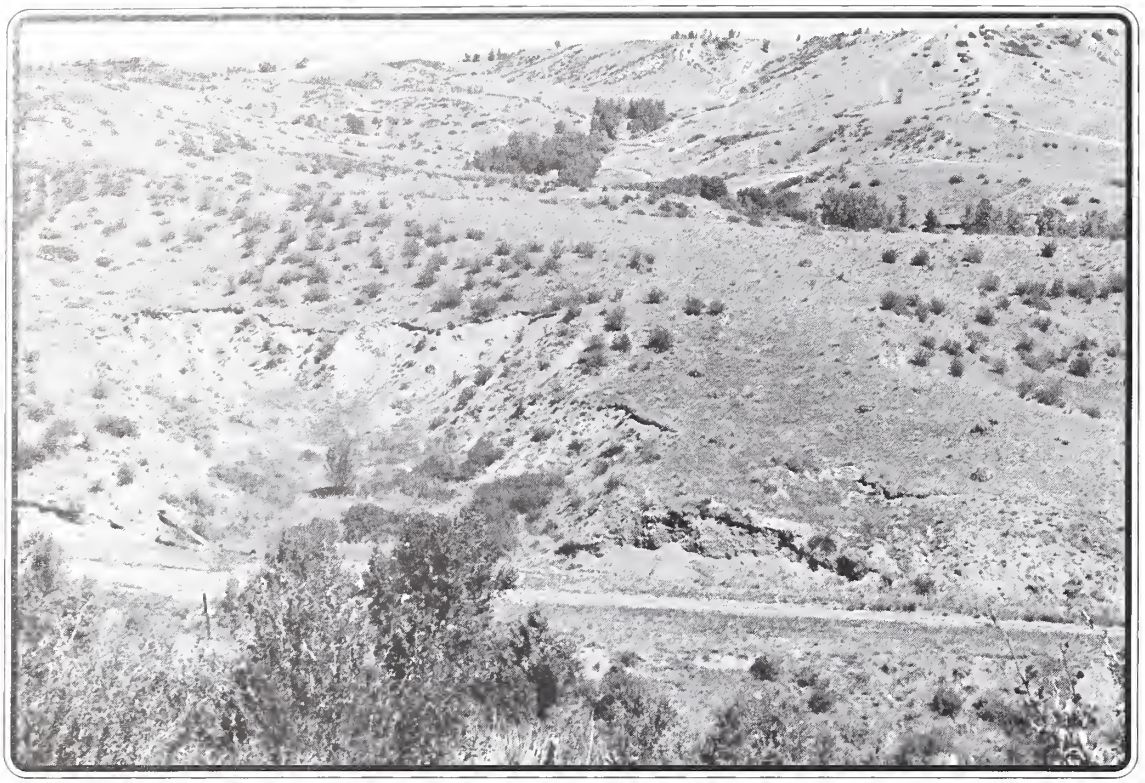
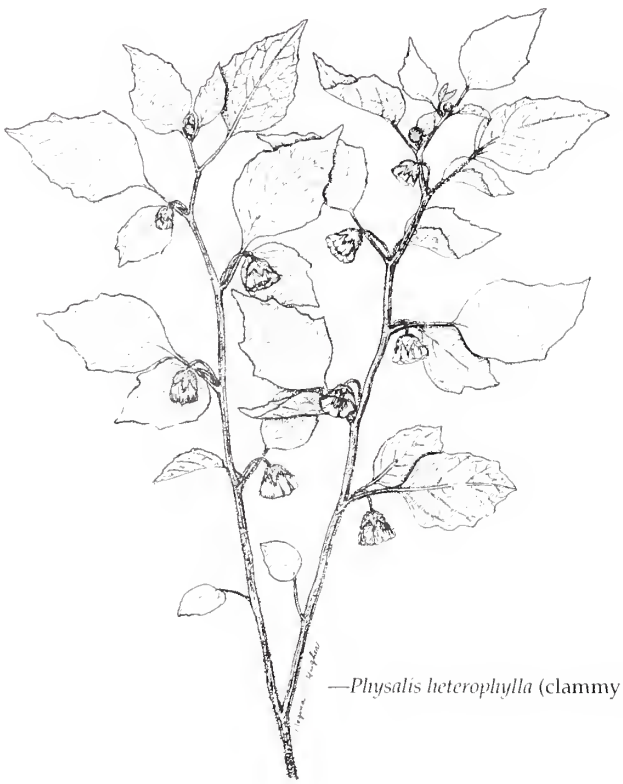


Figure 75C.
July 30, 1986, same location as that shown in figure 75A and 75B. (Photo No. 1986-154)



—*Physalis heterophylla* (clammy groundberry)

Ingraham Ranch

The ranch of Milton Ingraham, 11 miles northeast of Colorado Springs, was photographed in 1905 (figure 76A). Plant cover in the valley was chiefly *Bouteloua gracilis*, occupying from 20 to 70 percent of the surface. In this grass cover were also *Psoralea tenuiflora*, *Eriogonum effusum*, and *Cryptantha minima*. Toward the hills, *Aristida longiseta*, *Bouteloua hirsuta*, *Calamovilfa longifolia*, *Andropogon gerardii*, and *Schizachyrium scoparium* were also found. On the ridges, the species were *Juniperus monosperma*, *Pinus ponderosa*, *Cercocarpus montanus*, *Rhus trilobata*, and *Ribes cereum*, but no *Quercus gambelii*. Here were also *Bouteloua curtipendula*, *Artemisia frigida*, *Eriogonum jamesii*, and *Oryzopsis hymenoides*. Along the gully were *Populus sargentii*, and below the house was a large area of *Symphoricarpos occidentalis*.

Figure 76B shows the same area 44 years later, in 1949. The plant species were the same as for figure 76A. In 1949 the large area of *Symphoricarpos occidentalis* to the right of the ranch house in figure 76A had given way to *Iva xanthifolia* and *Chenopodium album*. The ranch house was gone, but *Populus sargentii* trees marked the location. In the right foreground, a channel that could be seen forming in 1905 was well developed in 1949. The gully across the center was freshly cut in 1905, but the banks were broken and partly healed in 1949. The width had increased by the ratio of 1.2:1. The large gully on the right was deeper by a ratio of 1.4:1. In the center background, where two large gullies had developed, erosion appeared much greater in 1949 than in 1905. The small *Populus sargentii* trees in the gully at the right had increased in height by the ratio of 3.2:1; and the small *Rhus trilobata* at the left, in the proportion of 1.5:1. *Rhus trilobata* and *Cercocarpus montanus* had increased in number and size and seemed to have maintained themselves without loss during 44 years. The width of the gully in the back had increased in the ratio of 1.6:1. Some of the areas sparsely covered in 1905 had a denser plant cover in 1949.

In 1986, there was no sign of fresh erosion in the main gully, and it appeared to be identical in size and shape to what it was in 1949 (figure 76C). However, the side gullies in the foreground had eroded considerably since 1949. The *Populus sargentii* at the old ranch house location were gone, but some fenceposts still marked the location. Some of the large *Populus sargentii* along the gully were dead and were being replaced by younger trees. The *Juniperus monosperma* and *Pinus ponderosa* trees were larger, but the number of trees appeared to be the same. The shrubs in the background (mostly *Cercocarpus montanus*) showed no change and could be matched shrub for shrub in the 1949 and 1986 photographs. The grass cover remained essentially the same as in 1949, and this area seemed relatively stable.

Figure 76A.
August 5, 1905, ranch of Milton Ingraham, about 11 miles northeast of Colorado Springs. (Sec. 35, T13S, R65W; Photo No. 1905-109)

Figure 76B.
July 18, 1949, same location as that shown in figure 76A, now part of the Banning-Lewis ranch. (Photo Nos. 1949-132, F-1-1949)

Figure 76C.
August 6, 1986, same location as that shown in figure 76A and 76B. (Photo No. 1986-132)

CHANGES IN LAND USE IN EASTERN COLORADO, 1908 TO 1985

Changes in Mapping Control

During 1908 and 1909 Shantz made many maps and field notes of the natural vegetation and crops grown in different parts of eastern Colorado. At that time few roads followed section lines; usually the roads led off at an angle across sections, often going for miles without encountering a fence. Traveling by horse and buggy across this terrain made it difficult to estimate distance and, often, directions as well; but despite these difficulties, Shantz mapped the area with a fair degree of accuracy.

By 1949 almost all sections were fenced, and roads followed the section lines. While it was often difficult for Shantz to cover the exact areas mapped in 1908-09, the areas he observed were nearly the same and thus provide the basis for measuring changes in vegetation and land use. His detailed maps cannot be included here but they were summarized. Copies were included with the full report, which was filed with the U.S. Forest Service February 10, 1953, and in supplement 1, dated May 22, 1953.[1] The following sections describe some of the major changes that occurred over approximately the last 80 years.

[1] Copies of the reports, maps, and supplement had been filed with the U. S. Forest Service, Rocky Mountain Forest & Range Experiment Station, Fort Collins, Colorado: but in 1985, neither the reports nor the maps could be located. Duplicate copies of reports are on file in the Shantz special collection, University of Arizona Library, Tucson, Arizona; but the maps apparently are lost.

Yuma Township

Land-use maps for 1908 and 1949 were located, and a new map was drawn for 1985; these maps, which cover the township in which the town of Yuma is located (T2N, R48W), are shown in figure 77A, 77B, and 77C. The maps point out the major changes from grassland to cropland that took place over a 77-year period in this area of mostly hard land. Changes are summarized in table 2.

The most striking change is the overall reduction of native grassland from 86.7 percent of the area in 1908 to 5.5 and 6.2 percent in 1949 and 1985, respectively, with a corresponding increase in the cultivated area from 13.3 percent in 1908 to 93.8 percent in 1985.

This increase in amount of farmland was accompanied by changes in the relative amounts of land devoted to the various crops (table 2). In 1908 corn was planted on nearly half the cultivated land. By 1949, corn occupied less than one-sixth of the dryland cultivated area, and in 1985 less than one-hundredth of the dryland area. The big gain was made by wheat. In 1908 wheat and fallow land together accounted for about one-third of the cultivated acreage, but in 1949 they represented over two-thirds, and in 1985 slightly over half of the cropland acreage. The major change between 1949 and 1985 was in irrigated land—none in 1949 to over one-third of the cultivated land in 1985. Most irrigation was by center-pivot systems. The principal irrigated crop was corn, but some beans were also grown.

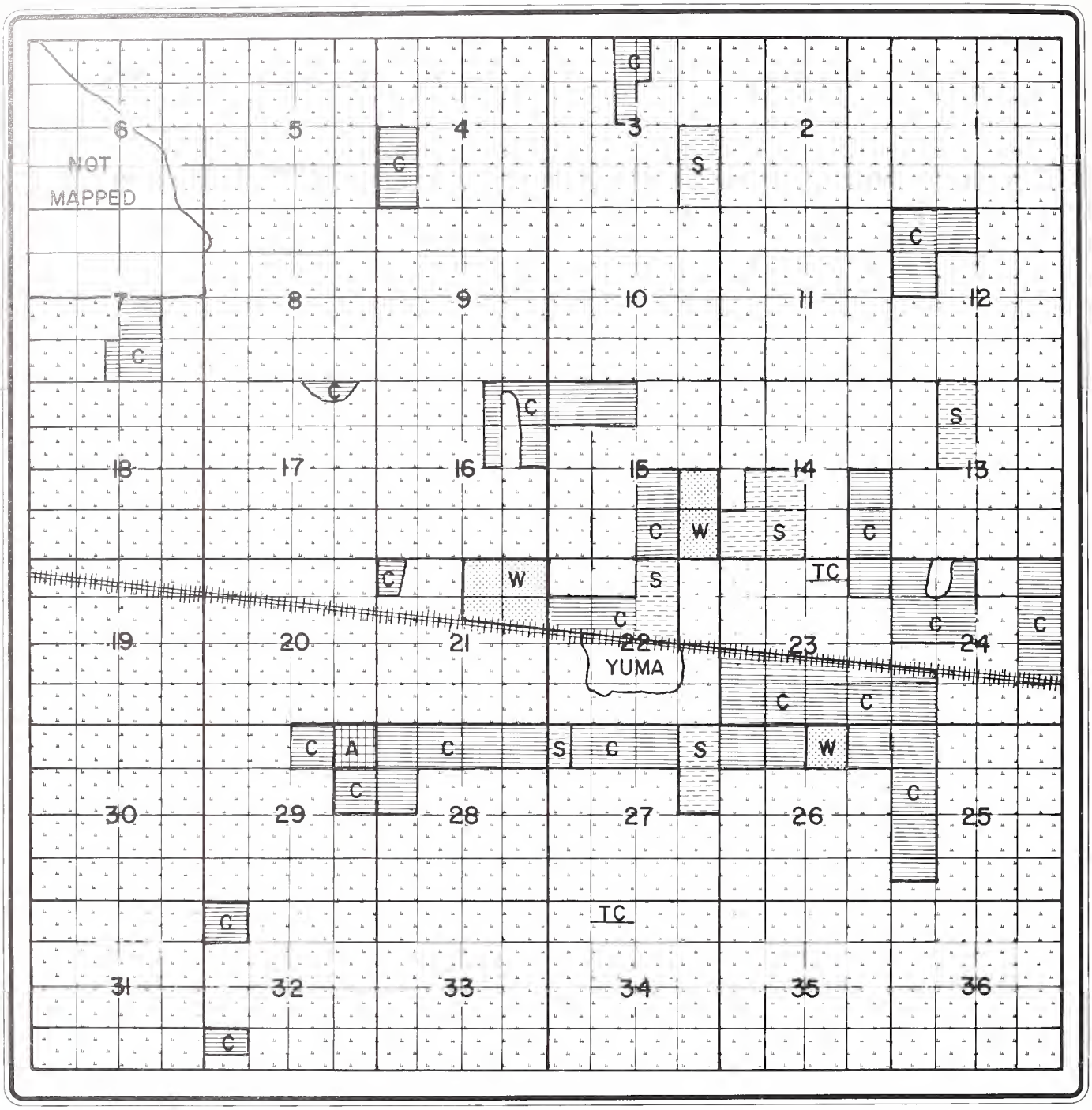


Figure 77A.
Land use in Yuma Township (T2N, R48W) in 1908.

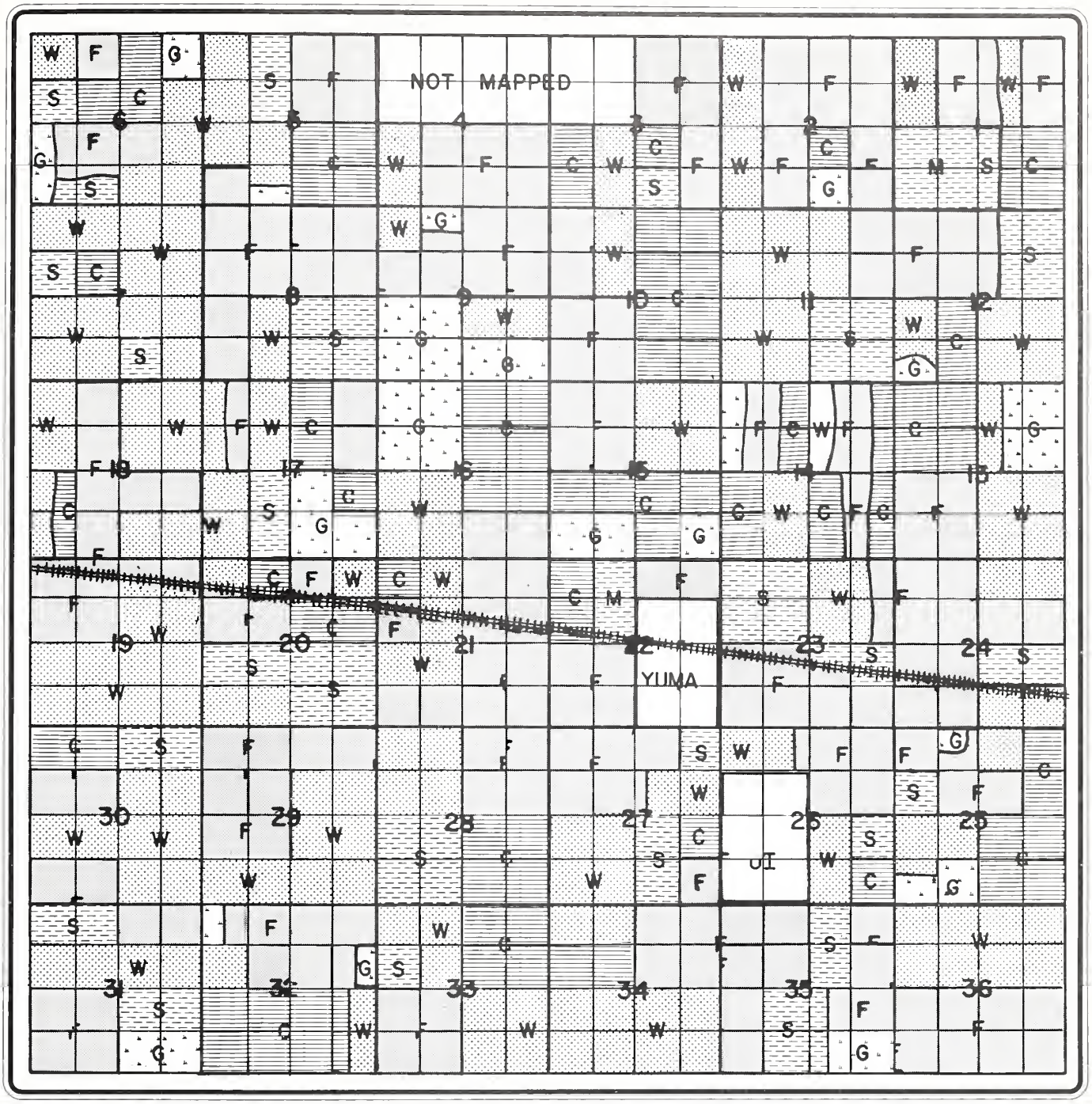


Figure 77B.
Land use in Yuma Township (T2N, R48W) in 1949.

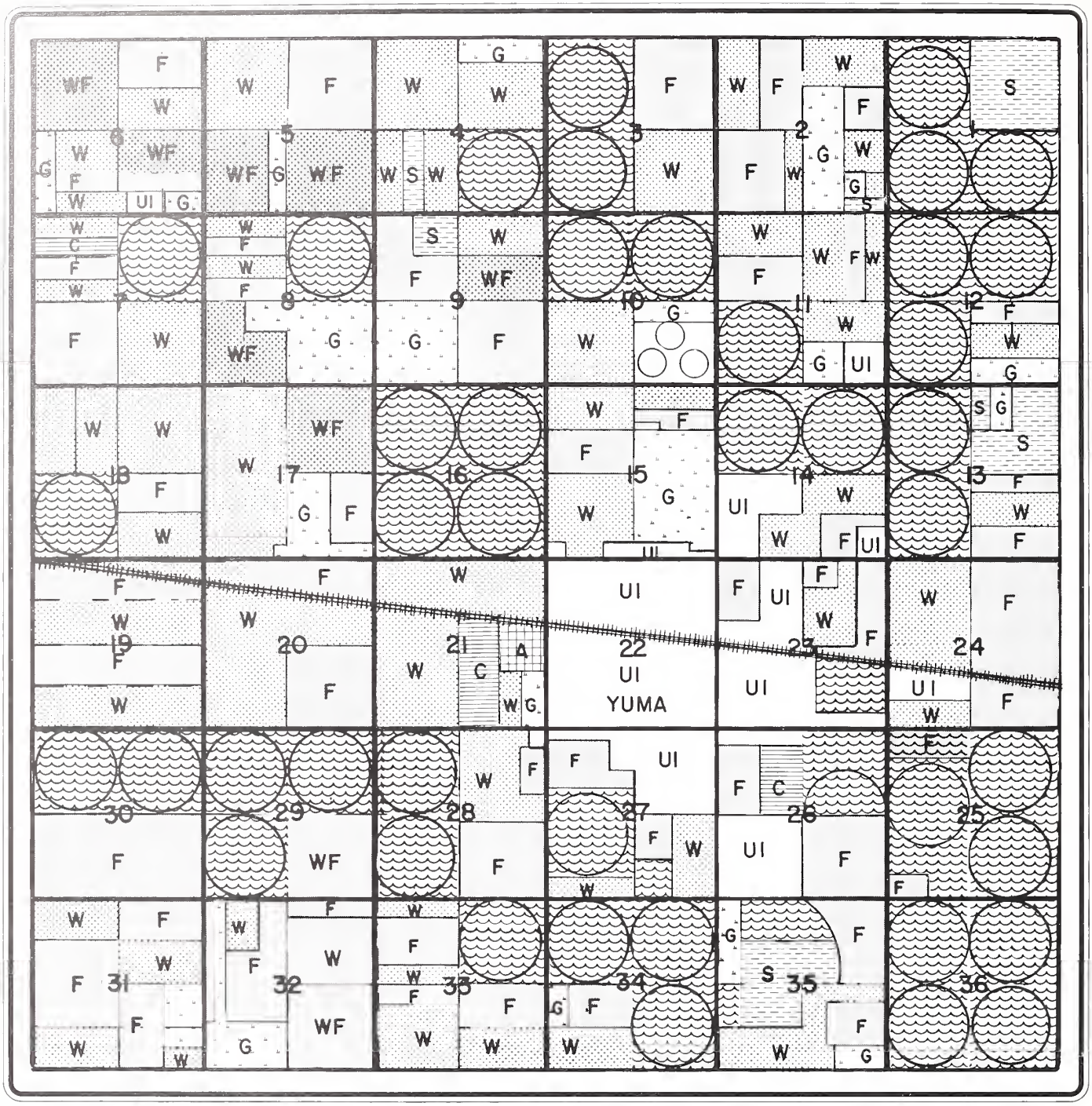


Figure 77C.
Land use in Yuma Township (T2N, R48W) in 1985.

Table 2.
Land use on hard land (shortgrass land) in township 2 north, range 48 west, in which Yuma, Colorado, is located, recorded as percentage of the area of the sample

Vegetation	35 sections		
	1908	1949	1985
Crop			
Fallow	3.6	37.4	22.1
Wheat	0.9	32.0	27.5
Wheat-fallow mix	—	—	6.0
Corn (dryland)	6.4	15.0	0.8
Sorghum and millet	2.0	10.1	2.4
Alfalfa and smooth bromegrass	0.2	0.0	0.2
Tree claims	0.2	0.0	0.0
Irrigated	0.0	0.0	34.8
Total crop	13.3	94.5	93.8
Native			
Shortgrass (*Bouteloua gracilis-Buchloe dactyloides*)	81.2	5.5	6.2
Wiregrass	0.2	0.0	0.0
Wiregrass (reestablished)	5.3	0.0	0.0
Bunchgrass	0.1	0.0	0.0
Dry pools	0.1	0.0	0.0
Total native	86.7	5.5	6.2

—*Medicago sativa* (alfalfa)

Yuma and Washington Counties

Less than 32 percent of the area near Vernon remained in native grassland in 1908-09, which was less than usual in eastern Colorado at the time (table 3). Over the years the land in native grass was still further reduced until in 1949 less than 10 percent was in native sod, and some of this land may have been cropped at one time and allowed to go back to native vegetation. The principal cropping change was from corn to wheat. In 1908-1909 corn occupied 39 percent of the cultivated land and wheat only 16 percent; in 1949 corn occupied 3 percent of the cultivated area while wheat occupied 48 percent or, if fallow wheat land is included, 93 percent.

In the vicinity of Yuma the original vegetation included both shortgrass and wiregrass types. In 1908-1909, 18 percent of the land was under cultivation and 82 percent was native, of which about 9 percent was at some stage of secondary succession. Corn was the principal crop. Sorghum, including some proso and Kursk millet, but chiefly amber sorghum, was next in abundance, and wheat last. Fallow was often followed by corn, sorghum, or wheat.

The amount of cultivated land near Yuma increased from less than 20 percent to more than 80 percent between 1908-1909 and 1949. Wheat, which was planted in about 1 percent of the total land area in 1908-1909, had, along with fallow, increased to nearly 70 percent of the total area by 1949.

In the area south of the Arickaree River in the vicinity of the town of Joes, the soils tend to be coarser in texture than those near Yuma and were characterized by shortgrass and wiregrass vegetation in the ratio of about 3:5. In 1908-1909, 84 percent of the area was in native grass and 16 percent in cropland. By 1949 the percentages were nearly reversed, and the area in native grass was about evenly divided between shortgrass and wiregrass types. Here, as elsewhere in the State, the major crop increase was in wheat. Of very minor importance in 1908-1909, wheat together with fallow land (most of which would be planted to wheat) occupied about 70 percent of the cropland in 1949.

In 1908-1909 about 80 percent of the sandhills areas in the triangle bounded by the towns of Wray, Akron, and Cope were in native grass. Of the bunchgrass land, only the most stable land had a nearly pure stand of *Schizachyrium scoparium*. The remaining 20 percent of the area traveled by Shantz (which naturally included the more stable land and excluded areas of more open sand and blowouts that were less suitable for cultivation) was cultivated. During high-precipitation years, sandy lands did not equal the hard lands in crop production, but in drier years they always excelled and seldom failed to produce at least a small crop. During the driest years crops on hard lands failed entirely. However, great caution was taken in the use of sandy land to avoid wind erosion.

In 1908-1909, wheat growing was seldom attempted on this land. In 1949, despite the strong incentive of high prices to increase the wheat acreage, only 2.5 percent of the area was in wheat. About 4.5 percent was in fallow—a terribly dangerous practice on sandy soil and one which horrified the oldtimers. *Schizachyrium scoparium*, which occupied 74 percent of the area in 1908-1909 had all but disappeared in 1949 and was nowhere abundant enough to map. The native vegetation following the death of the *Schizachyrium scoparium* was a very weedy stage of sandhills-mixed, with *Bouteloua gracilis*, *Bouteloua hirsuta*, *Aristida longiseta*, *Calamovilfa longifolia*, and *Artemisia filifolia* as important perennials. While the total native grassland decreased from 80 percent in 1908-1909 to 64.5 percent in 1949, sandhills-mixed increased from 6.4 percent in 1908-1909 to 64.5 percent. Cultivated land increased from 20 percent to 35.5 percent during the same time.

Because the maps and field data from 1908-1909 and 1949 were not available, no data on acreage were taken in 1985 for these areas.

Table 3.
Changes in land use in eastern Colorado in the vicinity of Vernon, Yuma, Joes, and the sandhills, recorded as percentage of area mapped

	Vicinity of —							
	Vernon		Yuma		Joes		Wray-Akron-Cope sandhills	
	16 Sections 1908-09	15 Sections 1949	63 Sections 1908-09	34 Sections 1949	18 Sections 1908-09	26 Sections 1949	74 Sections 1908-09	59 Sections 1949
Crop								
Corn	26.9	3.0	5.3	10.9	2.5	14.6	10.2	24.7
Sorghum	8.0	3.0	2.0	3.8	0.4	9.7	0.9	3.8
Wheat	10.6	43.6	0.8	31.9	1.4	24.2	0.5	2.5
Fallow	22.7	40.6	9.6	36.2	11.8	31.3	8.2	4.5
Total cultivated	68.2	90.2	17.7	82.8	16.1	79.8	19.8	35.5
Native								
Shortgrass	31.8	9.8	58.6	15.1	33.0	10.6		
Wiregrass			16.0	2.1	50.9	9.6		
Wiregrass (reestablished)			7.7	0.0				
Bunchgrass							73.8	0.0
Sandhills-mixed							6.4	64.5
Total native	31.8	9.8	82.3	17.2	83.9	20.2	80.2	64.5

—*Kochia scoparia* (Belvedere summercypress)

Comparison of Changes on Hard Land and Sandy Soils

Between 1908-1909 and 1949 there were marked differences in the use of hard lands and sandy areas, both in total acreage devoted to crops and in the relative areas devoted to individual crops. These differences are summarized in table 4 in terms of land use on (1) shortgrass and wiregrass land and (2) bunchgrass and sandhills-mixed land.

In 1908-1909, hard land was characterized by a cover of shortgrass, largely of *Bouteloua gracilis* and *Buchloe dactyloides* (figure 3A). Land with slightly coarser textured soils was characterized chiefly by an overstory of *Aristida longiseta* and *Psoralea tenuiflora* and a ground cover of *Bouteloua gracilis* (figure 14A). Much of the hard land that had been plowed and later abandoned was dominated by *Aristida longiseta*, which Shantz called wiregrass.

Vegetation on more stable sandy land consisted mostly of *Schizachyrium scoparium* and included scattered *Bouteloua hirsuta*, *Andropogon hallii*, *Calamovilfa longifolia*, and *Aristida longiseta* (figure 23A). The less stable sandy land was characterized by sandhills-mixed vegetation that consisted of all the species just mentioned plus *Artemisia filifolia*, but *Schizachyrium scoparium* was not as prominent.

Table 4 shows that fallow on sandy land decreased from 8.2 in 1908-1909 to 4.5 percent in 1949. Nevertheless, the total acreage of unprotected land exposed to winds in 1949 was greater than that in the early years. Much of the fallow on sandy land in 1908-1909 was not clean fallow. Rather, it was in the process of reverting to native vegetation; and often the vegetation was in an annual weed stage. In contrast, the land mapped as fallow in 1949 was bare or nearly so.

In 1949 there were no areas of *Schizachyrium scoparium*. Most of the vegetation in the area had changed, consisting of *Calamovilfa longifolia*, *Bouteloua hirsuta*, and *Bouteloua gracilis*; some *Stipa comata* and *Artemisia filifolia*; and many weedy annuals.

The hard land clearly was the favored cropland, increasing from about a fifth to four-fifths of the total land area under cultivation between 1908-1909 and 1949. During the same time, the cultivated area on the sandy land changed only from one-fifth in 1908-1909 to a little more than a third in 1949. By 1949, more than twice as much of the hard land was in cultivation compared to sandy land. The sandy land under cultivation in 1949 included many of those lands most susceptible to severe wind erosion.

During the period 1908-1909 to 1949, corn was the crop of choice on the sandy land. It was planted on half the sandy land cultivated in 1908-1909, increasing to two-thirds in 1949. On the hard land, corn occupied about a third of the cultivated land in 1908-1909, but only about an eighth in 1949. Wheat was favored as a crop on the hard land, where wheat plus fallow amounted to nearly four-fifths of the total cultivated acreage compared to about a fifth on the sandy land in 1949. This low amount on sandy land may have been due in part to the wind erosion risk on fallow land and also the damage to the planted crop by early-season winds.

On the basis of total acreages, cultivated land increased more than three times on hard land, and less than twice as much on sandy land. Native grass decreased from 77 to 13 percent on hard land and from 80 to 64 percent on sandy land.

Because the original field data and maps from 1908-1909 and 1949 were not available, no attempt was made to collect similar data in 1985.

Table 4.
Summary of land use on shortgrass and wiregrass land as compared with the use of bunchgrass and sandhills-mixed land in eastern Colorado (in percentage of the area sampled)

Vegetation	Shortgrass and wiregrass land		Bunchgrass and sandhills-mixed land	
	1908-09 132 sections mapped	1949 112 sections mapped	1908-09 74 sections mapped	1949 59 sections mapped
Crop				
Corn	7.9	12.0	10.2	24.7
Sorghum	2.9	7.1	0.9	3.8
Wheat	1.8	31.7	0.5	2.5
Fallow	10.0	36.0	8.2	4.5
Total crop	22.6	86.8	19.8	35.5
Native	77.4	13.2	80.2	64.5
Total	100.0	100.0	100.0	100.0

—*Helianthus annuus* (sunflower)

Land Use Along Selected Roads in Eastern Colorado

Shantz also documented land use along several highways in eastern Colorado in 1908 and 1949. Most of these highway transects were revisited in 1985 (table 5). Many of these areas are farther west than those previously discussed, and less land was plowed compared to the land nearer the eastern boundary of Colorado. As suggested by the lack of grassland, the area between Wray and Vernon would be classed as one of the best areas for dryland farming in Yuma County, and perhaps all of eastern Colorado.

In general terms, eastern Colorado is now a one-crop (wheat) land except where it is irrigated. In many instances large companies plant and harvest the wheat crop. In July the area is filled with migrating combine harvesters. Wheat in great quantities is hauled to elevators that dominate the skyline, or it is sometimes piled loosely on the ground.

Much soil erosion has taken place in this region, particularly on the sandy lands. In the event of future drought and wind (and nothing is as sure), the stage is set for future dust storms, since there is little evidence of soil-binding practices.

Table 5.
Estimates of land use in 1908, 1949, and 1985

Location	Year	Native	Cultivated	Corn	Sorghum	Wheat	Fallow	Other crops	Irrigated
		Percent							
Limon to Seibert	1949	30.3	69.7	2.2	4.7	36.7	25.2	0.9	0.0
Seibert to Cope	1949	28.2	71.8	12.3	4.9	30.0	24.6	0.0	0.0
	1985	30.8	69.2	0.0	0.0	29.3	29.8	0.5	9.6
Cope to Akron	1949	27.4	72.6	5.7	2.8	26.7	35.9	1.5	0.0
	1985	20.3	79.7	0.0	2.4	39.2	37.5	0.3	0.3
Akron to Yuma	1908	85.9	14.1	—	—	—	—	—	—
	1949	3.2	96.8	16.1	15.1	37.6	28.0	0.0	0.0
	1985	12.8	87.2	1.4	9.2	34.8	30.5	0.0	11.3
Yuma to Haxtun	1949	13.4	86.6	5.2	7.2	42.5	31.7	0.0	0.0
	1985	10.7	89.3	0.0	6.0	33.1	35.1	0.0	15.1
Vernon to Wray	1908	23.2	76.8	38.9	7.4	11.0	19.5	0.0	0.0
	1949	7.8	92.2	0.8	7.1	39.8	44.5	0.0	0.0
	1985	0.0	100.0	0.0	0.0	41.0	29.0	3.0	27.0

SUMMARY AND CONCLUSIONS

Environmental Factors That Affect Vegetation

Vegetation in eastern Colorado demonstrates both change and stability. Shortgrass is the most stable of the vegetational types studied, changing primarily in amount of production in response to weather. Most of the wiregrass type, of which we have records, has been plowed, making it difficult to determine changes. The bunchgrass type has declined greatly, and *Schizachyrium scoparium* is gone from many areas; but reasons for the decline are unclear. The sandhills-mixed type shows some loss of tallgrass species and, usually, a dramatic increase in *Artemisia filifolia*. The tree claims have all disappeared. Shrubs (particularly *Quercus gambelii*) and trees on the western edge of the Great Plains have shown almost no change in the area they occupy, but they have increased in density and height.

Causes for change, or lack of it, are not often clear. The effects of weather, soil permeability, land use, and grazing pressure, individually and in combination, cannot be measured in a study such as this one, but only inferred. Photographs and plant lists from the early 1900's, the 1940's, and the 1980's were obtained during periods when precipitation tended to be favorable, so photographs taken in 1949 and 1985-1986, in particular, frequently represent average to above-average growing conditions. The downward trend in precipitation during the period of this study, if it is valid, may help explain the loss of *Schizachyrium scoparium* from many areas. The severe droughts of the 1930's, the 1950's, and the 1970's, in combination with the way the land has been managed have almost certainly contributed to some of the changes. We have no records of grazing management or intensity, but in general, grazing pressure has probably been less after World War II than it had been earlier in the century.

Most ecological and range management research has ignored the subtle effects of soil permeability and other edaphic factors on the composition and structure of native vegetation. Classical ecology, particularly as it embraces monoclimax concepts, largely ignores small differences in soil texture. Yet, the early work of Shantz, to an extent verified in this study, indicates that small differences in soil texture (such as the difference between a loam and a sandy loam) can have dramatic effects both on species composition of native vegetation and upon subsequent agricultural uses of such lands. Changes in the species composition of vegetation that were previously attributed to the effects of heavy grazing, such as the apparent increase in *Aristida longiseta* on some grazed shortgrass lands, are more correctly attributed to the effects of soil texture and permeability than to a grazing-induced decrease in the shortgrasses (Hyder et al. 1966).

The dynamic vegetational changes in quantity of biomass, in plant cover, and in species composition are the most noticeable characteristic of the grassland types. Weather variations can cause grasses to thrive and provide almost total ground cover, then to nearly disappear and leave bare ground, and then to return and provide a dense cover again, all in a relatively short period. The sequence of photographs at Sheridan Lake graphically demonstrate this phenomenon. Species often come and go in the plant community for no obvious reason. For example, in some areas *Stipa comata* was not even mentioned as being present in earlier photographs, but in 1985 was the dominant species. *Stipa comata* and some other species showed this tendency to appear and disappear, and some of the changes recorded in the photographs were probably a direct result of such periodic eruptions and declines of individual species.

Shortgrass Type

Shortgrass is the most common of the grassland types on the Great Plains of Colorado and occurs primarily on loam soils. The wiregrass type is more common on the coarser textured and more permeable soils. *Bouteloua gracilis* is the dominant species throughout the shortgrass type. *Buchloe dactyloides* is a common codominant, particularly in the eastern part of the shortgrass region and is usually less common on sandy land and land closer to the mountains. *Buchloe dactyloides* is common on go-back land and areas recovering from drought or other disturbance, because of its ability to spread by stolons. Given enough time and favorable growing conditions in the area photographed, *Bouteloua gracilis* can return as well. Species composition of the shortgrass type is a function of latitude, altitude, weather, soil conditions, topography, and disturbance. Following a sequence of wetter than average years, midgrasses may become important in the community. *Agropyron smithii* is uncommon on the upland shortgrass sites in Colorado, but it is common in swales and floodplains that receive runoff water.

Shortgrass vegetation, particularly *Bouteloua gracilis*, is extremely resilient. It can recover from seemingly total destruction resulting from drought, plowing, or severe overgrazing. Many acres of the most productive shortgrass land have been plowed and planted to wheat at one time or another. There also are large acreages, particularly in the lower rainfall areas, where the native vegetation has not been disturbed. Go-back land is common where farmers found that dryland farming proved too risky. Almost all the shortgrass type has been grazed continuously by domestic

livestock since the latter part of the 19th century, and essentially no ungrazed shortgrass exists today.

Wiregrass Type

The wiregrass type is dominated by *Bouteloua gracilis* and commonly codominated by *Buchloe dactyloides*. *Aristida longiseta*, midgrasses, and deep-rooted broadleaf species occur as an overstory and make use of the water available at deeper depths because *Bouteloua gracilis* and *Buchloe dactyloides* tend to have shallower roots. The wiregrass type typically has more available soil water than the shortgrass type either because of more precipitation or, more commonly, because the wiregrass type usually occurs on sandy loam soils with much higher permeability than the soils of the shortgrass type. These coarser textured soils are able to store more water at greater depths than the heavier textured soils of the shortgrass type, where much of the rainfall runs off. Thus, high soil permeability is the factor determining the presence of *Aristida longiseta* and other deep-rooted species. High soil permeability as a factor is true even in northern Weld County, where rainfall is much lower than it is farther east in Colorado (Hyder et al. 1966). The wiregrass type discussed here is not to be confused with the *Aristida longiseta* stage of secondary succession that occurs when the shortgrass type has been severely disturbed. Very little of the original wiregrass type now remains because most of it has been plowed and planted to wheat. Where it persisted the wiregrass type, like the shortgrass type, showed little apparent change during the period of this study.

Bunchgrass Type

Perhaps the greatest change in any of the grassland areas has occurred in the bunchgrass type, and this change has been due to the disappearance of *Schizachyrium scoparium* from many locations. Shantz noted that relatively pure stands of *Schizachyrium scoparium* growing on large acreages in 1908 had been replaced by other species, mostly shortgrasses and wiregrass-type species and some sandhills-mixed species, by 1949. The disappearance of *Schizachyrium scoparium* in eastern Colorado is probably related to a shift toward a drier climate, recurrent severe droughts, increases and decreases in grazing pressure, and destruction of the bunchgrass type by cultivation. The bunchgrass type represents a transition between the wiregrass type and the sandhills-mixed type, and the bunchgrass type can grow on sandier soils than the wiregrass type can. The bunchgrass type also can grow on breaks and other areas of rough topography in soils that range from clayey to sandy; but the plants tend to be more widely spaced, and the presence of rock may result in deep water (and hence deep root) penetration. *Schizachyrium scoparium* can even invade severely disturbed areas, such as the abandoned roadbed at Beecher Island (see figure 21B) and the railroad bed near Chief Creek. The Beecher Island region and a few small areas, most of which were disturbed areas, were the only places where *Schizachyrium scoparium* was found in any abundance in 1985. In many respects, this species appears to have functioned much like a pioneer species in secondary succession. Perhaps, once it is gone from a stand, it is unable to become reestablished because of the competition from aggressive species, such as *Bouteloua gracilis*. Also, one must wonder about availability of seeds of *Schizachyrium scoparium*.

Sandhills-Mixed Type

Two substantial changes have occurred in the sandhills-mixed type. The first has been a large reduction in tallgrass species and *Schizachyrium scoparium* and a concomitant increase in midgrass and shortgrass species. This change occurred mainly during 1908 to 1949 and is presumed to have resulted from the combined effects of dry years and heavy grazing pressure. The second major change has been an increase in the amount of *Artemisia filifolia*. Some *Artemisia filifolia* has always been present, but it increased dramatically since 1949. In many locations it is so abundant that it gives the vegetation the appearance of a sagebrush-grass community. There is no clear evidence to explain the increase in *Artemisia filifolia*, but sustained moderate to heavy grazing and the probable reduction in the frequency of wildfires are suspected as possible causes.

During the first two-thirds of the 20th century, very little land sustaining the sandhills-mixed type was cultivated for dryland agriculture because of the potential for severe wind erosion of the sandy soils. In recent years, however, particularly in Yuma County, large acreages have been plowed and are now producing crops under center-pivot irrigation systems. Should irrigation be discontinued, either for economic reasons or because of declining water level of the Ogallala Aquifer, large areas currently being cultivated may be abandoned, leading to severe erosion and development of large blowouts.

Blowouts

Blowouts occur within sandhills type land, but are considered separately here because of their distinctive vegetation and the secondary succession that occurs within them. In 1985 most of the blowouts in Yuma County were stable. However, small areas of bare or nearly bare sand along the southeast edge still were present on many of the craters. The series of favorable precipitation years that preceded 1985 probably accounted for the stability at that time. In general, plant

succession in blowouts follows the pattern described in the section "Stages of Natural Revegetation in the Crater of Dodd's Large Blowout." The succession was developed in the early years of this study. However, in 1985 few blowouts had reached stage 6 of the succession, and most had stopped at stage 5. In 1985, great differences were noted between northeast-facing and southwest-facing slopes within the blowouts. The southwest-facing slopes tended to be more xeric, and the successions had seldom progressed beyond stage 4. The northeast-facing slopes had developed a more mesic vegetation characteristic of later successional stages. Both *Yucca glauca* and *Artemisia filifolia* are now more common within the blowouts than they were in the early years of this study. *Mentzelia nuda* is a ubiquitous species that occurs equally in all stages of succession. *Muhlenbergia pungens* appears to have become more common than it was in previous years. In many places, it appears to be dead; but, at the same time, it is not being replaced by other species. It appears to be a dominant primarily in the early successional stages or in areas subject to recurrent disturbance, but its abundance may also be due to climatic perturbations, for example, in areas where the droughts of the 1930's, 1950's, and 1970's perhaps truncated plant succession. Because enough sand has been removed from the larger blowouts to expose the underlying loess, vegetation in the bottoms of the blowouts is frequently shortgrass. The smaller blowouts have sandy bottoms with sandhills-mixed vegetation growing there.

Tree Claims

As nearly as can be determined, all tree claims in eastern Colorado are now gone, although a few trees around some of the farmsteads may be remnants of former tree claims. Of the species that were planted, *Fraxinus pennsylvanica* was the most successful. Of more recent plantings (after 1900) around farmsteads and in windbreaks, *Pinus ponderosa*, *Juniperus scopulorum*, and *Elaeagnus angustifolia* had good survival. Tree claims that had the best survival rates usually were on permeable soils, many of which had native stands of wiregrass or bunchgrass. In soil with shortgrass type vegetation, shallow water penetration was apparently a limiting factor for tree survival. Survival was highest on the northwest side of the tree claims because the prevailing winter winds are from the northwest, resulting in more snow accumulation on that side. Conversely, hot, dry winds from the southeast are common in the summer, and these winds create additional evapotranspirational stress on the southeast side of the tree claims. Thus, the seasonal wind patterns caused the tree claims to die out on the southeast side and permitted the trees on the northwest side to survive the longest.

Dryland planting of trees on the scale of the original tree claims appears doomed to failure in eastern Colorado. Most of the successful tree plantings now growing in eastern Colorado, including some windbreaks, cover areas that are much smaller than the original tree claims, receive supplemental water, are cultivated to eliminate competing vegetation, have been designed so that lateral roots can spread into adjacent areas to obtain water, are protected from grazing damage, have been designed to encourage snow accumulation, or have some combination of the above characteristics.

Foothills and Black Forest

Vegetation in the foothills and Black Forest remained remarkably stable during the period of study. *Quercus gambelii* appeared neither to increase in number nor to invade any grassland. In many cases, shrubs in the 1986 photographs could be matched individually with those in the earlier photographs. The only observable difference was an increase in the height of the plants. *Cercocarpus montanus* showed equal permanence, and at some locations increased in number, but did not seem to grow as much as the unpalatable *Quercus gambelii*, probably because of grazing by deer. Although *Cercocarpus montanus* multiplied within some of the earlier sparse stands, it showed no sign of occupying new areas.

Trees on Cheyenne Mountain have increased in both size and number. Many seedling trees were planted in this area in 1918-1919 by a crew that included one of the authors (William G. McGinnies), and these plantings probably were at least partly responsible for the increase in number of trees. In the Black Forest area, there was little evidence of trees moving into the grassland. Some new trees have become established since this study began, but these are mostly within the confines of the previously existing timbered areas. The few trees that have become established outside the forested areas seem to be exceptions and constitute a rare occurrence.

Land Use

The two greatest changes in land use have been the increase in the amount of land under cultivation between 1908 and 1949 and the increase in irrigation between 1949 and 1985. The acreage in dryland farming increased rapidly starting with World War I and continued to increase until the drought of the 1930's, when many dryland farms were abandoned and allowed to return to native grassland (go-back land). During and following World War II, much of the go-back land plus some additional native grassland was plowed and planted to wheat, particularly in northeast and east-central Colorado. In southeast Colorado, the amount of go-back land in 1985 was considerable.

Although we have no records, it appeared that much less of this region was put back into dryland farming following World War II than areas farther north, probably because of the risks of dryland farming in southeast Colorado. In 1908, the most commonly grown dryland crop was corn, but in 1949 and 1985, the predominant dryland crop was wheat. Of great concern to us in 1985 was the large acreages of wheatland, particularly in east-central Colorado, that were clean-tilled with no evidence of conservation practices to protect the land against wind erosion. This is an area subject to periods of hot, dry, windy weather such as occurred during the Dust Bowl era. If such weather were to return, severe wind erosion would almost certainly follow.

Irrigation on land overlying the Ogallala Aquifer increased greatly during the past 20 years. Deep-well pumps are used to bring the water to the surface and apply it, mainly by center-pivot sprinkler systems, not only to land formerly used for dryland agriculture, but also on land that is too sandy for dry-farming methods. Thus, some large acreages that previously sustained sandhills-mixed vegetation are now cultivated and irrigated. Corn is the principal crop grown on the irrigated land. Some studies indicate that the Ogallala Aquifer is being depleted. Should depletion be complete and the center-pivot systems be removed, these sandy soils would become subject to wind erosion and development of large blowouts.

The principal change in land use in the Colorado Springs-Monument region has been the conversion of grazing land to urban development. Much of the area surrounding and on The Mesa has been developed for housing and other urban uses, and subdivisions are starting to move up the large gully from the east. Ranchettes, estates, and other suburban developments are now common from Palmer Lake to Monument to Eastonville to Colorado Springs, and signs posted by land developers indicate that much more of this land will be developed for residential use in the future.

—*Chenopodium album* (lambsquarters goosefoot)

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APPENDIX A

List of scientific plant names used and common name equivalents.

Scientific Name	Common Name
Abronia fragrans Hook.	snowball sandverbena
Acer saccharinum L.	silver maple
Agropyron cristatum (L.) Gaertn.	fairway wheatgrass
Agropyron smithii Rydb.	western wheatgrass
Amaranthus powellii S. Wats.	Powell amaranth
Amaranthus retroflexus L.	redroot amaranth
Ambrosia psilostachya DC.	western ragweed
Ambrosia trifida L.	giant ragweed
Andropogon gerardii Vitman	big bluestem
Andropogon hallii Hack.	sand bluestem
Anemone patens L.	American pasqueflower
Antennaria parvifolia Nutt.	littleleaf pussytoes
Antennaria rosea (D.C. Eat.) Greene	rose pussytoes
Antennaria sp	pussytoes
Apocynum androsaemifolium L.	spreading dogbane
Arctostaphylos uva-ursi (L.) Spreng.	bearberry
Arenaria fendleri A. Gray	Fendler sandwort
Argemone polyanthemos (Fedde) G.B. Ownbey	many-flowered pricklepoppy
Aristida longiseta Steud.	red threeawn, wiregrass
Artemisia bigelovii Gray	Bigelow sagebrush
Artemisia dracunculus L.	falsetarragon
Artemisia filifolia Torr.	sand sagebrush
Artemisia frigida Willd.	fringed sagebrush
Artemisia ludoviciana Nutt.	Louisiana sagebrush
Asclepias arenaria Torr.	sand milkweed
Aster ericoides L.	heath aster
Astragalus bisulcatus (Hook.) A. Gray	twogrooved milkvetch
Astragalus crassicarpus Nutt.	groundplum milkvetch
Astragalus drummondii Dougl.	Drummond milkvetch
Astragalus gracilis Nutt.	slender milkvetch
Astragalus mollissimus Torr.	woolly loco
Astragalus pectinatus (Hook.) Dougl.	narrowleaf poisonvetch
Astragalus sericoleucus A. Gray	silky crophaca
Atriplex canescens (Pursh) Nutt.	fourwing saltbush
Bahia oppositifolia (Nutt.) DC.	plains bahia
Bouteloua curtipendula (Michx.) Torr.	sideoats grama
Bouteloua gracilis (H.B.K.) Lag.	blue grama
Bouteloua hirsuta Lag.	hairy grama
Bouteloua simplex Lag.	mat grama
Bromus inermis Leyss.	smooth bromegrass
Bromus tectorum L.	cheatgrass
Buchloe dactyloides (Nutt.) Engelm.	buffalograss
Calamovilfa longifolia (Hook.) Scribn.	prairie sandreed
Calylophus serrulata (Nutt.) Raven	shrubby evening primrose
Campanula rotundifolia L.	common harebell
Carex filifolia Nutt.	threadleaf sedge
Carex stenophylla Wahl.	needleleaf sedge
Castilleja integra A. Gray	wholeleaf paintedcup
Cenchrus pauciflorus Benth.	mat sandbur
Cercocarpus montanus Raf.	true mountainmahogany
Chenopodium album L.	lambsquarters goosefoot

Chenopodium leptophyllum (Moq.) Wats.	slimleaf goosefoot
Chloris virgata Swartz	feather windmillgrass
Chrysothamnus graveolens (Nutt.) Hall	greenplume rubber rabbitbrush
Chrysothamnus pulchellus (A. Gray) Greene	southwest rabbitbrush
Cirsium plattense (Rydb.) Fern.	Platte thistle
Cirsium undulatum (Nutt.) Spreng.	wavyleaf thistle
Cleome serrulata Pursh	bee spiderflower
Comandra pallida (DC.) M.E. Jones	pale bastardtoadflax
Commelina crispa (Woot.) Palmer & Steyerm	curlyleaf dayflower
Croton texensis (Klotzsch) Muell. Arg.	Texas croton
Cryptantha crassisepala (Torr. & Gray) Greene	plains hiddenflower
Cryptantha jamesii (Torr.) Payson	James cryptantha
Cryptantha minima Rydb.	least cryptantha
Cryptantha thyrsiflora (Greene) Payson	cluster cryptantha
Cryptantha virgata (Porter) Payson	wand cryptantha
Cycloloma atriplicifolium (Spreng.) Coult.	tumble ringwing
Cyperus filiculmis Vahl.	thread-stemmed flatsedge
Dalea enneandra Nutt.	slender indigobush
Distichlis stricta (Torr.) Rydb.	inland saltgrass
Dyssodia papposa (Vent.) Hitchc.	prairie dogweed
Echinocereus viridiflorus Engelm.	greenpitaya echinocereus
Elaeagnus angustifolia L.	Russianolive
Erigeron canadensis L.	horseweed fleabane
Erigeron canus A. Gray	hoary fleabane
Erigeron pumilus Nutt.	low fleabane
Eriogonum alatum Torr.	wing eriogonum
Eriogonum annuum Nutt.	annual eriogonum
Eriogonum effusum Nutt.	spreading eriogonum
Eriogonum glandulosum Nutt.	glandular eriogonum
Eriogonum jamesii Benth.	James eriogonum
Erysimum asperum (Nutt.) DC.	plains erysimum
Euphorbia robusta (Engelm.) Small	robust euphorbia
Euphorbia serpyllifolia Pers.	thymeleaf euphorbia
Eurotia lanata (Pursh) Moq.	winterfat
Evolvulus nuttallianus Roem. & Schult.	Nuttal evolvulus
Festuca arizonica Vasey	Arizona fescue
Festuca idahoensis Elmer	Idaho fescue
Festuca octoflora Walt.	sixweeks fescue
Frasera speciosa Dougl.	showy frasera
Fraxinus pennsylvanica (Marsh.)	green ash
Froelichia gracilis (Hook.) Moq.	slender snakecotton
Gaura coccinea Nutt.	scarlet gaura
Geranium caespitosum James	purple geranium
Gilia calcarea M.E. Jones	sticky gilia
Gilia longiflora (Torr.) G. Don	longflower gilia
Grindelia squarrosa (Pursh) Dunal	curlycup gumweed
Gutierrezia sarothrae (Pursh) Britton & Rusby	broom snakeweed
Haplopappus spinulosus (Pursh) DC.	ironplant goldenweed
Helianthus annuus L.	sunflower
Helianthus petiolaris Nutt.	prairie sunflower
Heterotheca villosa (Pursh) Shinners	hairy goldaster
Hilaria jamesii (Torr.) Benth.	galleta
Hordeum pusillum Nutt.	little barley
Hymenopappus filifolius Hook.	fineleaf hymenopappus
Hymenoxys acaulis (Pursh) Parker	stemless hymenoxys
Hymenoxys scaposa (DC.) Parker	barestem hymenoxys
Ipomoea leptophylla Torr.	bush morningglory

Iva xanthifolia Nutt.	rag sumpweed
Juglans nigra L.	black walnut
Juncus sp.	rush
Juniperus monosperma (Engelm.) Sarg.	one-seed juniper
Juniperus scopulorum Sarg.	Rocky Mountain juniper
Kochia scoparia (L.) Schrad.	Belvedere summercypress
Koeleria cristata (L.) Pers.	prairie junegrass
Lappula redowskii (Hornem.) Greene	bluebur stickseed
Lathyrus polymorphus Nutt.	showy peavine
Lepidium densiflorum Schrad.	prairie pepperweed
Lesquerella alpina (Nutt.) S. Wats.	alpine bladderpod
Lesquerella ludoviciana (Nutt.) S. Wats.	silver bladderpod
Liatris punctata Hook.	dotted gayfeather
Linum lewisii Pursh	Lewis flax
Linum rigidum Pursh	stiffstem flax
Lithospermum incisum Lehm.	narrowleaf gromwell
Lupinus plattensis S. Wats.	Nebraska lupine
Lygodesmia juncea (Pursh) D. Don	rush skeletonplant
Medicago sativa L.	alfalfa
Melilotus officinalis (L.) Lam.	yellow sweetclover
Mentzelia nuda (Pursh) Torr. & Gray	bractless mentzelia
Muhlenbergia montana (Nutt.) Hitchc.	mountain muhly
Muhlenbergia pungens Thurb.	sandhill muhly
Muhlenbergia torreyi (Kunth.) Bush	ring muhly
Oenothera albicaulis Pursh	prairie eveningprimrose
Oenothera latifolia (Rydb.) Munz	broadleaf eveningprimrose
Oenothera pallida Lindl.	pale eveningprimrose
Opuntia fragilis (Nutt.) Haw.	brittle pricklypear
Opuntia imbricata (Haw.) DC.	walkingstick cactus
Opuntia polyacantha Haw.	plains pricklypear
Oryzopsis hymenoides (Roem. & Schult.) Ricker	Indian ricegrass
Oxybaphus linearis (Pursh) Robinson	narrow-leaved four-o'-clock
Oxytropis lambertii Pursh	Lambert crazyweed
Palafoxia sphacelata (Nutt.) Cory	poisoning palafoxia
Panicum virgatum L.	switchgrass
Paronychia jamesii Torr. & Gray	James nailwort
Paspalum stramineum Nash	sand paspalum
Penstemon ambiguus Torr.	gilia penstemon
Penstemon angustifolius Nutt.	narrowleaf penstemon
Petalostemon oligophyllus (Torr.) Herman	slender white prairieclover
Petalostemon purpureum (Vent.) Rydb.	purple prairieclover
Petalostemon villosum Nutt.	silky prairieclover
Physalis heterophylla Nees	clammy groundcherry
Picea engelmannii (Parry) Engelm.	Engelmann spruce
Pinus edulis Engelm.	pinyon pine
Pinus ponderosa Laws.	ponderosa pine
Plantago patagonica Jacq.	Patagonia Indianwheat
Poa pratensis L.	Kentucky bluegrass
Polanisia trachysperma (Torr. & Gray)	roughseed clammyweed
Polygala alba Nutt.	white polygala
Populus sargentii Dode	plains cottonwood
Portulaca oleracea L.	purselane
Potentilla hippiana Lehm.	horse cinquefoil
Prunus besseyi Bailey	Bessey plum
Prunus virginiana L.	chokecherry
Pseudotsuga menziesii (Mirb.) Franco	Douglas fir
Psoralea lanceolata Pursh	lemon scurfpea

Psoralea tenuiflora Pursh	slimflower scurfpea
Quercus gambelii Nutt.	Gambel oak
Ratibida columnifera (Nutt.) Woot & Standl.	upright prairieconeflower
Redfieldia flexuosa (Thurb.) Vasey	blowoutgrass
Rhus trilobata Nutt.	skunkbush sumac
Ribes aureum Pursh	golden currant
Ribes cereum Dougl.	wax currant
Rosa arkansana Porter	Arkansas rose
Rumex venosus Pursh	veiny dock
Salix sp.	willow
Salsola iberica Sennen & Pau	Russianthistle
Salvia reflexa Hornem.	Rocky Mountain sage
Schedonnardus paniculatus (Nutt.) Trel.	tumblegrass
Schizachyrium scoparium (Michx.) Nash.	little bluestem
Sedum stenopetalum Pursh	wormleaf stonecrop
Senecio mutabilis Greene	variable groundsel
Sitanion hystrix (Nutt.) J.G. Smith	bottlebrush squirreltail
Solanum rostratum Dunal	buffalobur nightshade
Sophora sericea Nutt.	silky sophora
Sorghum bicolor (L.) Meonch	sorghum
Sorghastrum nutans (L.) Nash	yellow Indiangrass
Sphaeralcea coccinea (Pursh) Rydb.	scarlet globemallow
Sporobolus airoides (Torr.) Torr.	alkali sacaton
Sporobolus cryptandrus (Torr.) A. Gray	sand dropseed
Stanleya pinnata (Pursh) Britton	dessert princesplume
Stephanomeria tenuifolia (Torr.) H.M. Hall	slender wirelettuce
Stipa comata Trin & Rupr.	needle-and-thread
Stipa robusta (Vasey) Scribn.	sleepygrass
Symphoricarpos occidentalis Hook.	western snowberry
Thelesperma megapotamicum (Spreng.) Kuntze	rayless greenthread
Thermopsis rhombifolia Rich.	prairie thermopsis
Tradescantia occidentalis (Britton) Smyth	prairie spiderwort
Tribulus terrestris L.	puncturevine
Tridens pilosus (Buckl.) Hitchc.	hairy tridens
Trisetum montanum Vasey	Rocky Mountain trisetum
Ulmus americana L.	American elm
Xanthium strumarium L.	common cocklebur
Yucca glauca Nutt.	small soapweed
Zea mays L.	corn